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Exploring teachers' use of technology in teaching and learning mathematics in KwaZulu-Natal schools

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It is often claimed that technology can be used as a tool that can facilitate teaching and learning and contribute to learners' achievement. This article reports on a study about how KwaZulu-Natal mathematics teachers use, access and integrate technology in the teaching and learning of mathematics. A questionnaire containing closed and Likert scale questions regarding the use of technology, was distributed to 75 KwaZulu-Natal mathematics teachers. The findings reveal that the technology used most commonly by the group for teaching mathematics is calculators. Almost all the teachers reported that they never use computers in their teaching of mathematics. Although the teachers reported that they do not use computers in teaching and learning, about 80% of the participants conveyed a positive view that using technology improves learners' understanding of mathematics. The findings further indicate that the teachers' propensity to use technology in instructional practice is associated with demographic factors related to teaching experience, gender, level of study and participation in professional learning activities. The study also showed that teachers who have access to internet instructional resources have higher levels of confidence in teaching mathematics and hold broader beliefs about the nature of mathematics and the aims of teaching mathematics than the teachers who do not use the internet for instructional purposes.

Introduction

The rapidly growing influence of technology in the 21st century has led to calls for teaching and learning to be transformed to prepare learners to compete within the global knowledge economy. Learning in the 21st century requires the collaboration of well-trained teachers, working in well-equipped classrooms and using technology innovatively to support a constructive learning atmosphere (Molnár, 2008). Technology allows learners to move beyond focusing on basic information to more global issues by providing them with access to innovative applications and tools (Van Melle & Tomalty, 2000). The teaching environment can thus be transformed by teachers if they integrate technology effectively in preparing lessons, designing learning activities and conducting assessments.

The potential of technology to transform the classroom is recognised by the South African Department of Education (DOE) which supports the idea of introducing Information and Communication Technology (ICT) in South African schools (Department of Basic Education [DBE], 2016; DOE, 2007). Teachers are urged to develop learners with 'relevant modern skills that match the needs of our changing world' (DBE, 2016, p. 3). Learners should be able to 'access, analyse, evaluate, integrate, present and communicate information; create knowledge and new information by adapting, applying, designing, inventing and authoring; and function effectively in a knowledge society by using appropriate ICT … skills' (DOE, 2007, p. 3). The education department states that ICT can recreate a classroom atmosphere while also advancing higher-order thinking skills in learners (DBE, 2010). For example, it enables teachers and learners to increase the level of comprehension, reasoning, problem-solving, thinking and employability (DOE, 2004, 2007). The DOE further highlights five targets of the use of ICT which involve 'entry (basic ICT skills), adoption and adaptation (integration of ICT in teaching and learning), and appropriations and innovation (specialisation and innovation in ICT education)' (DOE, 2007, p. 9).

Thus, teachers are encouraged to develop their capability and innovation to make the best use of the potential of digital devices in augmenting learner performance (Ndlovu & Lawrence, 2012). It has become incumbent upon teachers to attain relevant and appropriate ICT knowledge and skills to be able to integrate it appropriately in teaching, learning and administration (DOE, 2007). However, the digital divide, which is the disparity in the level of development of and access to ICT between different sectors, presents a challenge to educational innovations. Insufficient basic

ICT infrastructure in rural schools poses a challenge for teachers, which is not necessarily the case in urban schools (Dzansi & Amedzo, 2014). Ndlovu and Lawrence (2012) emphasise that ICT policy has been poorly implemented across South African schools, more specifically for those schools that serve disadvantaged areas, thus adding to the digital divide. Many disadvantaged schools cannot keep up with the well-resourced schools in terms of integrating ICT into their teaching and learning approaches. The limited use of ICT is not simply caused by the shortage of resources, but it is dependent on the ways in which the teachers utilise the available educational tools in their teaching (Ndlovu & Lawrence, 2012). Research highlights particular teacher factors such as age, experience, confidence, beliefs, as well as gender which seem to influence the extent to which teachers take up technology in their teaching practices (Ali, 2015; Beswick, 2007; Brändström, 2011; Cavas, Cavas, Karaoglan, & Kisla, 2009; Choi, 1992).

This article addresses the use of technology in teaching mathematics and statistics. Recent advances in technology have unlocked entirely new directions for education research. In this study, we try to make a contribution towards finding out more about the use of technology in KwaZulu-Natal schools. The study also explores the relationship between teachers' use of technology and their confidence and beliefs about the ways in which mathematics should be taught. To our knowledge, no previous study has focused on these issues. Furthermore, the study looks at some factors that may have a relationship with the use of technology. It is hoped that the knowledge contributed by this study will help the education department in their planning and provision for teacher support in the use of technology. We also hope that this study will help other researchers identify areas in the field of mathematics teachers' use of technology which need more attention.

Literature review

The integration of technology in teaching and learning is not intended to replace traditional methods, but to support schools to improve teaching and learning (Tishkovskaya & Lancaster, 2012). Some technology tools include 'power points, web-based games, the internet, projectors, smart boards, Elmos, calculators, videos, DVDs and music' (Moore, 2012).

The GAISE College Report (GAISE College Report ASA Revision Committee, 2016) includes graphical calculators, statistical software packages, educational software, applets, spreadsheets, classroom response systems, web-based statistics related resources, data repositories, online texts, and data analysis routines in their list of recommended technology tools.

ICTs, especially computers and internet technologies, support new ways of teaching and learning rather than simply allowing teachers and students to do what they have done before in a better way (Noor-Ul-Amin, 2013). However, for teaching and learning to improve, technologies must be used as cognitive tools for learning and not simply as an alternative delivery platform (Herrington, Reeves, & Oliver, 2010). Moore (2012, p. 14) reports that integrating technology in a mathematics classroom can promote the development of computational skills while also developing higher order mathematical skills. The view of Forster (2006) is that using technological tools can improve the learning of mathematics by allowing learners to pay attention to underlying properties and relationships instead of focusing on tedious complicated calculations that may sometimes detract from the intended outcomes. ICT provides opportunities for learning by helping learners to access, spread, renovate and share ideas and information, which is transmitted in integrated communication styles and designs.

Technological tools can also open up access to a wider variety of problem-solving strategies than those limited to paper and pencil strategies (Bansilal, 2015).

Tools such as online videos allow the students to vary the pace at which they can learn new material in mathematics (Bansilal, 2015). By providing access to different representations that help visualisation of mathematical objects, certain mathematics software can contribute to a deeper understanding of the concepts. Technology also opens up possibilities for developing statistical concepts by enabling the visualisation of the concepts (Sorto & Lesser, 2009); it can make the demonstration of complex abstract ideas easier while also providing multiple examples (Chance, Ben-Zvi, Garfield, & Medina, 2007). In teaching statistics, technology can aid students in learning to think statistically by facilitating access to real (and often large) data sets and fostering active learning. Thus it can allow a learner to explore concepts and analyse data, manage and visualise data, perform inference, and check conditions that underlie inference procedures (GAISE College Report ASA Revision Committee, 2016).

Purcell, Heaps, Buchanan and Friedrich (2013) describe the importance of internet and digital tools in teachers' work of teaching. They state that 'the greatest impact of the internet and other digital tools on their role as teachers has been access to more content and material for use in the classroom and a greater ability to keep up with developments in their field' (p. 51). Noor-Ul-Amin (2013) argues that networked computers with internet connectivity can increase learner motivation as it combines the media richness and interactivity of other ICTs with the opportunity to connect with real people and to participate in real world events. Kramarski and Feldman (2000) report that instruction that integrates the use of the internet in classrooms improves learners' motivation in learning and has positive effects on learners' reading comprehension. Brändström (2011) examined the influence of the use of the internet on planning and instruction by interviewing five upper secondary school teachers. The findings revealed that the teachers consider the internet as a valuable source of information and an important additional teaching tool. It also reduces teachers' work while facilitating quick exchanges (Higgins, 2003).

Some studies have reported that the use of technology also increases teachers' confidence in the content (Brändström, 2011; Buabeng-Andoh, 2012; Cassim, 2010; Cox, Preston, & Cox, 1999; Leendertz, Blignaut, Nieuwoudt, Els, & Ellis, 2013; Mumtaz, 2000; O'Dwyer, Russell, & Bebell, 2003; Remesh, 2013; Sabzian & Gilakjani, 2013; Yang, 2013). For instance, in Cox et al.'s (1999) study, teachers reported that using ICT increased their confidence. O'Dwyer et al. (2003) further found that higher teacher confidence is associated with the largest increased use for delivering instruction and, in particular, increased use for class preparation. Further findings showed a significant relationship between teachers' confidence and ICT applications (Albion, Jamieson-Proctor, & Finger, 2011; Tasir, Abour, Halim, & Harun, 2012).

Research conducted in South Africa reports that the use of computers tends to feature fairly extensively in the learning areas of language and mathematics, natural sciences and technology, and less in humanities and arts (Lundall & Howell, 2000). On the one hand, they found that in Grades 1 to 7 computers tend to be used mainly for drill and practice and problem-solving exercises; on the other hand, from Grade 8 upwards computers tend to be used for a greater variety of purposes in the teaching and learning process. They also mention that drill and practice exercises, although less prominent, continue to be used in Grades 8 to 12.

Leendertz et al. (2013) investigated the level of technological pedagogical content knowledge (TPACK) of mathematics teachers and how TPACK contributes towards more effective Grade 8 mathematics teaching in South African schools. Their findings indicate that, with the improvement of TPACK of mathematics teachers, their confidence increases in their ability to apply technology for teaching mathematics in South African schools. Teachers acknowledged that ICT promotes conversations with colleagues and peers regarding teaching and learning practices and gives a platform to express their teaching and learning accomplishments. ICT also enabled them to conduct their administrative work more efficiently, allowed them to facilitate interactive lessons, and promoted confidence in using a variety of teaching and learning strategies designed for teaching (Leendertz et al., 2013).

Sometimes the failure by teachers to integrate technology in their classrooms is because of problems that are beyond their control (Marwan, 2008; Mumtaz, 2000). Some challenges experienced by teachers when trying to implement ICT include insufficient ability of ICT specialist teachers to teach students computer skills, lack of computer accessibility, lack of time as well as lack of financial support (Mumtaz, 2000). Similarly, Buabeng-Andoh (2012) identified poor ICT skills, low teacher confidence, insufficient pedagogical teacher training, absence of suitable educational software, limited access to ICT, inflexible structure of traditional education systems as well as limiting curricula design as some of the reasons that inhibited take-up of technology by teachers. The application of technology in teaching can lead to complexity because of the demands of learning newer technologies (Koehler & Mishra, 2009). Cavanagh, Reynolds and Romanoski (2004) examined how the ICT learning culture reconciles student learning and curriculum implementation in the classroom. In their study, they found that students expressed high confidence in their capacity to use ICT in their learning, but teachers were uncertain about the extent to which the learning was sustained by the learners.

Teachers' beliefs about teaching and learning play a major role in their decisions about how to teach the content. Hollingsworth (1989) articulated that the way teachers implement new methods or programmes in their classrooms relates to whether teachers' beliefs correspond with the suggested new methods. Ernest (1989) emphasises the important role of teachers' beliefs, particularly in mathematics education, where these beliefs depend on individual teachers. Ernest argues that teachers have particular beliefs about the nature of mathematics and how it is best taught. For instance, beliefs that mathematics is computation stems from ideas about the nature of mathematics whereas beliefs that teaching mathematics should be shaped by alternative ideas stem from beliefs about teaching mathematics. Beswick, Callingham and Watson (2012) found that while some teachers agreed that mathematics is the same as computations and that telling learners the answer is an efficient way of facilitating their mathematics learning, other teachers of mathematics believe they should be involved with learners' thinking. Beswick et al. are of the view that teacher's beliefs about general principles related to the nature of mathematics, and the learning and teaching of mathematics (rather than the use of specific approaches), are what matter to student learning.

Several studies have focused on teachers' beliefs about technology (Cavas et al., 2009; Choi, 1992; Mueller, Wood, Willoughby, Ross, & Specht, 2008; O'Dwyer et al., 2005) as a factor that motivates teachers' use of technology. Some studies found a significant relationship between teachers' beliefs towards technology and their instructional technology practices (Ali, 2015; Mumtaz, 2000; Palak & Walls, 2009).

Further factors that have been explored with respect to teachers' use of ICT are gender and age. The findings of Choi (1992) revealed that females and young teachers hold a slightly higher computer literacy level than male teachers and older teachers. However, the older age group tended to have more positive attitudes toward the instructional use of microcomputers in comparison with the younger age groups. However, the results of the study indicated no relationship between the teachers' attitudes and their knowledge of microcomputers. On the other hand, Almekhlafi and Almeqdadi (2010) found that male teachers were more likely to use technology than female teachers. Gender and age were also discussed by Cavas et al. (2009) who found that Turkish science teachers' attitudes towards ICT did not differ regarding gender, but differed regarding age, computer ownership at home and computer experience. These authors state that factors influencing the use of technology include availability of computers in the classroom, sharing of resources, a supportive administration, strong support staff, environmental, personal, social and curricular issues. Similar findings indicated that school factors, personal factors as well as beliefs towards technology influence teachers' use of technology (Cubukcuoglu, 2013; Mumtaz, 2000). Mumtaz (2000) identified an important technical sustenance of 20 hours per week that was necessary for teachers and found that a positive attitude of the principal contributed to teachers' use of technology. These authors agree it is important to support teachers in using technology in teaching and learning.

Sabzian and Gilakjani (2013) identified two contributing factors to teachers' low self-confidence in using technology. The authors found that limited computer instruction could lead to teachers' low confidence level when they initiate computer activities and result in high anxiety about using computers. The second was poor motivation which could result in insufficient knowledge in using instructional technology even if computers are provided in the classroom for teaching and learning. Ali (2015) points out that teachers' poor knowledge in using technology may be due to a lack of professional training with computers and lack of teacher-centred experiences in education and the lack of technological devices. These studies emphasise the need for programmes that can provide effective computer instruction to teachers while also helping them gain experience in the use of the technological tools.

Using factor analysis, Leendertz, Blignaut, Ellis and Nieuwoudt (2015) validated a questionnaire for ICT development of mathematics teachers. They found that the first factor was related to 'teachers'expectation' (reliability of 0.92), which means that mathematics teachers expect the DOE, provincial departments and schools to work together to improve an ICT strategic plan in order to increase technology use. Based on their study, they emphasise that professional development courses are urgently needed to support teachers in integrating ICT into teaching and learning. The site of the training does not have to be confined to the school as Lundall and Howell (2000) point out that many schools indicated that some teachers have access to technology-related professional training opportunities that take place outside the school.

This article addresses the use of technology in teaching mathematic in KwaZulu-Natal schools. As illustrated by the literature, recent advances in technology have unlocked entirely new directions for education research and we briefly surveyed some of the more pertinent studies in this area. We first looked at the ways in which digital classrooms support students' learning, before moving to the use of particular tools for instruction such as the internet which is a focus of this study. We then reviewed studies that investigated the association between using technology and particular demographic factors. The literature review also included studies about challenges faced by teachers in trying to increase the use of ICT in their classrooms. This review serves as a useful foundation to look at the use of technology by a group of KwaZulu-Natal mathematics teachers, and to identify the factors that are associated with it.

Research design and methodology

This quantitative study is a part of a larger doctoral study by the first author, developed to investigate teachers' knowledge of, beliefs about and confidence in teaching mathematics (Umugiraneza, Bansilal, & North, 2016, 2017, 2018a, 2018b). Knowledge and skills in appropriate technological tools explored in this study are recognised as a part of the knowledge required to teach these concepts. The participants in this quantitative study were 75 mathematics teachers from Grades 4 to 12 from KwaZulu-Natal, who were part of a group of teachers who attended an in-service course. The course was designed to help develop statistical knowledge and skills of mathematics teachers particularly from schools with a poor overall performance in mathematics (North, Gal, & Zewotir, 2014; North & Scheiber, 2008). A questionnaire based on an existing instrument developed by Beswick et al. (2012) was used to probe various aspects of teachers' knowledge, beliefs and confidence related to the teaching and learning of mathematics and statistics. The original questionnaire (Beswick et al., 2012) focused on mathematics which we extended to the teaching of statistics and the use of technology in classrooms.

The questionnaire included several parts such as questions related to teachers' confidence and beliefs, teaching practices (lesson planning, teaching methods and assessments, etc.), predicting learners' responses and the use of technology.

In this article, we focus on the teachers' responses to items regarding the implementation of technology in their instructional practice. Teachers were required to respond to statements on a four-point Likert item scale with categories 1 ('never'), 2 ('rarely'), 3 ('sometimes') and 4 ('often') to indicate how often they integrated technology in teaching mathematics. They were also asked about their access to calculators, computers and the internet and the extent to which these were used for teaching mathematics in their classrooms. Teachers were also asked to rate their level of confidence in teaching mathematics topics using a three-point Likert item scale with categories 1 ('low'), 2 ('moderate') and 3 ('high'). Their beliefs about teaching and learning mathematics were rated using a three-point Likert item scale with categories 1 ('disagree'), 2 ('neutral') and 3 ('agree').

This research was underpinned by the following research questions: (1) To what extent do mathematics teachers incorporate technology into their teaching practices? (2) To what extent are teachers positive about using technology in the teaching of mathematics? (3) Is there any relationship between demographic factors and the use of technology in instructional practices?

Participants

Table 1 presents a description of the participants in terms of various demographic factors.

Table 1 shows that the study involved an almost equal number of female and male teachers, with the majority being 40 years or younger. More teachers (60%) were teaching Grades 10–12 (FET) than those who taught Grades 4–9 (GET), while 60.0% completed a bachelor's degree and 40.0% completed postgraduate studies. Only 21.3% were from quintile 4 or 5 schools. Table 1 further indicates that 68.0% of the participants have met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis as part of their professional learning, and 45.3% said that they integrate the National Curriculum Statement Grade R–12 in their teaching process.

Data analysis

The data were analysed using IBM SPSS Statistics 23 version (George & Mallery, 2016). The package was used to evaluate the connection between the use of technology for educational instruction purposes and teachers' confidence and beliefs. Moreover, it was used to identify the important factors that may influence teachers' ability to use technology.

We used cross tabulation with chi-square test of independence at significance level *alpha* equal to 0.05, to explore some relationships. The chi-square test is known as a general test designed to evaluate when the difference between observed frequencies and the expected frequencies under a set of theoretical assumptions is statistically significant (Michael, 2001).

This test is a standard statistical procedure to test whether there is evidence of a statistically significant relationship between two categorical variables, as opposed to the two categorical variables operating independently. It is assumed that if the *p*-value is less than 0.05, we conclude that a significant difference does exist. This test was accordingly used to determine whether there is a statistical significant relationship between teachers' use of technology (using technology in class or consulting the internet for educational instructions) and teachers' confidence (including beliefs). Effectively then, we were exploring whether using internet or technology in the classroom for educational instructions was a reliable relationship with the level of confidence in their ability to teach a variety of mathematics and statistics topics and positive beliefs about teaching in teaching mathematics and statistics.

TABLE 1: Participants by demographic factors.

Factors	Definition (codes)	Frequency (%)
Gender	Female (0)	37 (49.3)
	Male (1)	38 (50.3)
Level of education	Bachelor's degree (0)	35 (60.0)
	Postgraduate and above (1)	40 (40.0)
Age group	≤ 40 years (0)	44 (58.7)
	> 40 years (1)	31 (41.3)
Quintile school	Q1 (0)	15 (20.0)
	Q2 (1)	28 (37.4)
	Q3 (2)	16 (21.3)
	Q4 and above (3)	16 (21.3)
Phases	GET (Grade 4–9) (0)	30 (40.0)
	FET (Grade 10–12) (1)	45 (60.0)
Teaching experience	≤ 10 years (0)	45 (60.0)
	> 10 years (1)	30 (40.0)
Attended mathematics workshop	No (0)	30 (40.0)
	Yes (1)	45 (60.0)
Met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis	No (0)	24 (32.0)
	Yes (1)	51 (68.0)
Use National Curriculum Statement in teaching mathematics and statistics	No (0)	34 (45.3)
	Yes (1)	41 (54.7)

We further used a comparison of means (a standard test used to compare differences between means of two or more groups) to explore whether there appears to be a statistically significant relationship between teachers' demographics and their use of technology in the different instructional practices. This test was used to examine the magnitude of the difference between two groups in terms of using technology.

Effect size reported in the output of the comparison of means is a name given to a family of indices that measure the magnitude of a treatment. It can help to see how much of a practical significance any result has (Becker, 2000; Cohen, 1988; Kotrlik & Williams, 2003). Hence, it was used to examine the magnitude of the difference between two groups in terms of using technology. Most of the effect sizes are less than 0.3; this indicates that the difference between groups of demographic factors in terms of using technology in teaching practice is small. Differences observed will thus be deemed to be significant if the *p*-value is less than 0.05 and the effect size is bigger than 0.3. Mean plots are used to see if the mean varies between different groups of the data. They were further used to explore the factors that may influence teachers to integrate technology in their teaching practice.

Ethical considerations

All ethical considerations stipulated by the University of KwaZulu-Natal were adhered to. Out of the group of 136 teachers who were approached to take part in the study, only 75 opted to participate. The participants were guaranteed anonymity and were also given the choice to withdraw from the research if they wanted to. Permission to carry out the research was granted by University of KwaZulu-Natal with the protocol number HSS/1529/015D.

Findings

We start by exploring the extent to which the teachers have access to calculators, computers and the internet in teaching mathematics, followed by details about the instructional purposes for which the technology is used. Thereafter we report in more detail on the differences in confidence and beliefs of teachers who use the internet for instructional purposes, and those who do not. This section is organised according to the research questions of the study.

Research question 1: To what extent do mathematics teachers use technology in their teaching practices?

Access to technology

Table 2 displays the results regarding the use of calculators and computers. Of the 75 teachers who were surveyed, only 49 (65%) teachers reported that in the schools where they were teaching calculators were used to teach and learn mathematics and statistics, even though calculators were commonly available. When asked about access to computers, there were even fewer teachers who enjoyed this privilege. There were only 33 (44%) teachers who reported that computers were available in the schools where they teach; only 21 (28%) said that computers were used to teach mathematics and statistics at the schools. Twenty (26.7%) had access to the internet and 19 (25.3%) said that internet was used for educational instruction.

Reports about the availability of computers at schools suggest similar figures to those reported by the teachers in this study. In 2015, it was found that 33.2% of schools had computers (South Africa Institute of Race Relations, 2015). Even though, in the current study, the availability of computers in schools was reported at approximatively 44%, only 28.5% of the teachers reported that these were used for teaching mathematics and statistics, which represents a limited use of technology.

The use of computers and calculators in teaching mathematics and statistics was disaggregated by the grade in which teachers were teaching. Table 3 indicates that 84.4 % of the teachers who were teaching Grades 10–12 mostly used calculators to teach mathematics, compared to 36.7% of teachers for Grades 4–9. On the other hand, only 40.0% of teachers who were teaching in Grades 10–12 reported that they used computers in mathematics and statistics teaching and learning, whereas only 10.0% of teachers in Grades 4–9 reported that they used computers in the classroom.

It is evident that in the schools represented in the study, the use of computers in the classroom is still at very low levels and much effort is needed to sensitise teachers to using computers for improved teaching of mathematics and statistics. This finding shows that the DOE (2007) recommendation that the use of ICT in the classroom should aim to develop a range of skills ranging from basic ICT skills to developing specialisation and innovation in ICT education is unlikely to be met under these conditions. It is clear that teachers would need much assistance and continuous professional teacher development on the implementation of information technology pedagogical knowledge in relation to integrating ICT in the teaching of mathematics (Cassim, 2010). Given that more than half the teachers do not have computers available at their schools, it is unrealistic to expect that these teachers would be able to take on the vision of the DOE in using ICT to improve the learning outcomes in the education system (DOE, 2007).

TABLE 2: Access to technology.

Question	No	Yes
	Frequency (%)	Frequency (%)
Are calculators available in your school?	26 (34.7)	49 (65.3)
Do you use calculators for teaching mathematics or statistics	26 (34.7)	49 (65.3)
Are computers available?	42 (56.0)	33 (44.0)
Do you use them for teaching mathematics and statistics	54 (72.0)	21 (28.0)
Do any of the computers learners use have access to the internet?	55 (73.3)	20 (26.7)
Do you use the internet for educational instructional purposes?	56 (74.7)	19 (25.3)

TABLE 3: The use of calculators and computers by grade.

Grades	Calculators		Computers	
	Yes (%)	No (%)	Yes (%)	No (%)
4–9	11 (36.7)	19 (63.3)	3 (10.0)	27 (90.0)
10–12	38 (84.4)	7 (15.6)	18 (40.0)	27 (60.0)

The instructional purposes for which the technology is used

Mishra and Koehler (2006) agree that the connection between technology and teaching can transform the conceptualisation and the practice of teacher education, teacher training and teachers' professional development. Teachers can use technology in different ways, such as in simple drill and practice tasks.

Drill and practice mathematics software offers teachers a relatively simple way to use technology in the classroom (Kuiper & De Pater-Sneep, 2014). Teachers could also use technology in more complex tasks such as using simulations in investigating real-life data. Table 4 indicates how often technology (computers) is implemented in different teaching practices. It can be noted from Table 3 that most teachers reported that they never used technology for any of the instructional activities mentioned. It is clear that most of the teachers in the study group were not using technology at all, not even in the most rudimentary way. Activities such as collecting and retrieving data from computers are associated with exploring data in real-life applications. The use of statistics in understanding and making informed decisions in real life is an important outcome of the subject, and these findings show that teachers need more help in this regard.

The use of the internet and teachers' confidence and beliefs

The data allowed us to look in more detail at the specific use of the internet for instructional purposes and to test whether this use was linked to certain factors. Ndlovu and Lawrence's

TABLE 4: Exploration of the use of technology in teachers' practice.

Teaching practice	Never	Rarely	Sometimes	Often
Drill and practice	46 (61.3)	7 (9.3)	12 (16.0)	10 (13.4)
Demonstrate statistics principles	42 (56.0)	9 (12.0)	9 (12.0)	15 (20.0)
Collect data using sensors or probes (collecting data using software)	48 (64.0)	13 (17.3)	6 (8.0)	8 (11.7)
Retrieve or exchange data	47 (62.7)	8 (10.7)	12 (16.0)	8 (10.7)
Solve and compute statistical problems	46 (61.3)	8 (10.7)	10 (13.3)	11 (14.7)
Take a test or quiz	41 (54.7)	8 (10.7)	11 (14.7)	15 (20.0)

Note: Data are shown as frequency with percentage in brackets.

(2012) view is that access to ICT enables quality use for educational purposes. It is expected that a teacher who makes use of the internet as an additional teaching tool will most likely earn their students' respect and regard, which in turn may motivate teachers to develop more innovative indeas about teaching. Some studies contend that teachers with more access to the Web for instructional purposes had higher levels of self-determination and that teachers with better computer access had lower computer nervousness and more computer self-efficacy (Liu & Kleinsasser, 2015). Thus, access to technology may be a factor that builds up teachers' knowledge.

We now investigate the links between the use of the internet and teachers' confidence and beliefs.

Teachers' confidence in teaching mathematics

Recent studies articulate that there exists a connection between teachers' confidence and the use of technology (Brändström, 2011; O'Dwyer et al., 2003; Sabzian & Gilakjani, 2013). Sabzian and Gilakjani (2013) argue that the lack of computer instruction often accounts for teachers' low confidence levels when they initiate computer activities. In this study, we explored whether teachers who use the internet for educational instruction purposes are confident in their ability to teach mathematics. We considered topics such as percentage, fraction, decimal, inference and prediction, measurement, pattern and algebra, mental computation, pie graphs and histograms, range and variations, ideas of sampling and data collection, and so on.

The results showed a statistical significant relationship between using the internet for educational instructional purposes and teachers' confidence in teaching mathematics or statistics topics. It can be noted from Table 5 that teachers who use the internet for instructional purposes expressed a high confidence in teaching percentages (χ^2 = 6.082(2), effect size = 0.285, *p*-value = 0.048), ratios and proportions (χ^2 = 9.835 (2), effect size = 0.362, *p*-value = 0.007), pie charts and histograms (χ^2 = 12.231 (2), effect size = 0.320, *p*-value = 0.048), pattern and algebra (χ^2 = 13.747 (2), effect size = 0.428, *p*-value = 0.001), measurement (χ^2 = 6.399 (2), effect size = 0.292, *p*-value = 0.041) and mental computation (χ^2 = 8.573 (2), effect size = 0.338, *p*-value = 0.014).

The values of effect sizes in Table 5, Table 6 and Table 7 ranged between 0.2 and under 0.4 which indicate moderate practical significance (Becker, 2000; Cohen, 1988; Kotrlik & Williams, 2003).

Teachers' beliefs about the goals of teaching mathematics

We further examined whether there is a significant relationship between using the internet for educational instructional purposes and teachers' beliefs about the nature of mathematics. It can be noted from Table 6 that teachers who reported that they use the internet were more likely to agree about some broad goals of teaching mathematics (as identified by Beswick et al., 2012) than those who did not. Teachers who reported that they use the internet agreed that mathematics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions) (χ^2 = 6.362 (2), effect size = 0.291, *p*-value = 0.042), statistics teaching should assist learners to develop a positive attitude to problem-solving (χ^2 = 6.050 (2), effect size = 0.284, *p*-value = 0.049), and statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning (χ^2 = 7.458 (2), effect size = 0.315, *p*-value = 0.024). The findings from Table 5 further show that the use of the internet for educational instructional purposes is associated with a stronger belief in the value of linking teaching to other key areas (χ^2 = 11.797 (2), effect size = 0.404, *p*-value = 0.003) as well as the need for applying statistics in real-life settings outside of the classroom situation (χ^2 = 8.701 (2), effect size = 0.397, *p*-value = 0.013).

TABLE 5: Using internet for instructional purposes and teachers' confidence.

Topics	Teachers' confidence	Using internet for instructional purposes					
		No	Yes	Total	χ^2 (*df*)	*p* value	Effect size
Percentages	Low	7 (12.5)	1 (5.3)	8 (10.7)	6.082 (2)	0.048	0.285
	Moderate	16 (28.6)	1 (5.3)	17 (22.7)	-	-	-
	High	33 (58.9)	17 (89.5)	50 (66.7)	-	-	-
Ratios and proportions	Low	11 (19.6)	0 (0.0)	11 (14.7)	9.835 (2)	0.007	0.362
	Moderate	23 (41.1)	4 (21.1)	27 (36.0)	-	-	-
	High	22 (39.3)	15 (78.9)	37 (49.3)	-	-	-
Pie graphs and histograms	Low	11 (19.6)	1 (5.3)	12 (16.0)	12.231 (2)	0.002	0.320
	Moderate	17 (30.4)	0 (0.0)	17 (22.7)	-	-	-
	High	28 (50.0)	18 (94.7)	46 (61.3)	-	-	-
Pattern and algebra	Low	11 (19.6)	0 (0.0)	11 (14.7)	13.747 (2)	0.001	0.428
	Moderate	19 (33.9)	1 (5.3)	20 (26.7)	-	-	-
	High	26 (46.4)	18 (94.7)	44 (58.7)	-	-	-
Measurement (Length, area, volume and time)	Low	9 (16.1)	0 (0.0)	9 (12.0)	6.399 (2)	0.041	0.292
	Moderate	20 (35.7)	4 (21.1)	24 (32.0)	-	-	-
	High	27 (48.2)	15 (78.9)	42 (56.0)	-	-	-
Mental computation	Low	14 (25.0)	2 (10.5)	16 (21.3)	8.573 (2)	0.014	0.338
	Moderate	25 (44.6)	4 (21.1)	29 (38.7)	-	-	-
	High	17 (30.4)	13 (68.4)	30 (40.0)	-	-	-

Note: Yes, No and Total columns are shown as frequency with percentage in brackets.

TABLE 6: Using internet for education instructional purpose and teachers' beliefs about teaching mathematics.

Variable	Level of agreement	Using internet for educational instructional purpose					
		No	Yes	Total	χ^2 (*df*)	*p* value	Effect size
Teachers' beliefs about goals							
Mathematics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions)	Disagree	1 (1.8)	0 (0.0)	1 (1.3)	6.362 (2)	0.042	0.291
	Neutral	14 (25.0)	00.0)	14 (18.7)	-	-	-
	Agree	41 (73.2)	19 (100.0)	60 (80.0)	-	-	-
Statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning	Disagree	1 (1.8)	0 (0.0)	1 (1.3)	7.458 (2)	0.024	0.315
	Neutral	16 (28.6)	0 (0.0)	16 (21.3)	-	-	-
	Agree	39 (69.6)	19 (100.0)	58 (77.3)	-	-	-
Goals of mathematics							
Connecting mathematics to other key learning areas	Low	20 (35.7)	1 (5.3)	21 (28.0)	11.79 (2)	0.003	0.404
	Moderate	21 (37.5)	5 (26.3)	26 (34.7)	-	-	-
	High	15 (26.8)	13 (68.4)	28 (37.3)	-	-	-
Using statistics outside of the classroom	Low	17 (30.4)	2 (10.5)	19 (25.3)	8.701 (2)	0.013	0.397
	Moderate	22 (39.3)	4 (21.1)	26 (34.7)	-	-	-
	High	17 (30.4)	13 (68.4)	30 (40.0)	-	-	-

Note: Yes, No and Total columns are shown as frequency with percentage in brackets.

TABLE 7: Teachers' beliefs about using technology in teaching and learning.

Teachers' beliefs	Disagree	Neutral	Agree	Total
Using technology to assess mathematics learning	3 (4.0)	12 (16)	60 (80.0)	75 (100)
Using technology helps with increasing learners' learning and understanding of statistics	11 (14.7)	15 (20)	49 (65.3)	75 (100)

Note: Data are shown as frequency with percentage in brackets.

Research question 2: To what extent are teachers positive about using technology in the teaching of mathematics?

Table 7 indicates that 60 (80%) of the 75 teachers in the study had a positive view regarding the use of technology to facilitate teaching and learning mathematics and statistics topics and 49 (65.3%) expressed a positive belief that it improves learners' understanding.

We further used a comparison of means to identify factors that may be associated with teachers' positive beliefs towards technology. It can be noted from Table 8 that teachers younger than 40 were more confident about the potential of technology to influence learning and understanding of statistics positively than was the case for teachers who were older than 40 (F = 4.912, p-value = 0.030, effect size = 0.251). They further believed that using technology helps to increase learners' learning and understanding of statistics (F = 8.886, p-value = 0.004, effect size = 0.329). Younger teachers were thus more positive about the use of technology to enhance understanding of statistics than older teachers. These young teachers are the same group that have 10 or fewer years of teaching experience and it will be shown that they are the group who are more likely to make use of technology in the classroom.

These results support the findings of Cavas et al. (2009), who reflected on science teachers' attitudes towards the use of technology in education. They found that the attitudes of young science teachers in their study (age group 20–35) were more positive about using technology in the classroom, which was significantly different from teachers in other age groups (36–49 and 50+). However, in another study, Choi (1992) found that older teachers displayed more positive attitudes towards computer use in education than was the case for the younger teachers in that study.

We further note that teachers who use the National Curriculum Statement in their teaching have positive beliefs that technology influences learning and understanding of statistics 40 (F = 7.164, p-value = 0.009, effect size = 0.299) and that using technology helps to increase learners' learning and understanding of statistics (F = 4.995, p-value = 0.028, effect size = 0.253). This indicates the importance of consulting the curriculum as the factor that encourages teachers to use technology in their teaching process.

Teachers largely agreed that the use of technology helps learners to develop their understanding of mathematics and statistics topics. Forty-nine out of 75 (65.3%) teachers said they believed that they would integrate technology into teaching and learning mathematics and statistics in the classroom.

Furthermore, the findings indicate that teachers who reported that they meet with a local group of teachers and discuss mathematics and statistics teaching on a regular basis as a part of their professional learning expressed positive beliefs that technology enhances learners' understanding (F = 10.541, p-value = 0.002, effect size = 0.355) and that using technology helps to increase learners' learning and understanding of statistics (F = 4.328, p-value = 0.041, effect size = 0.237). This finding indicates that in professional learning, teachers continue to acquire new skills while collaborating with other teachers and can share the best practice and integrate the innovations in the classroom. The DOE (2007) supports this idea that teachers' desires and benefits should be the driving force for their professional growth.

Research question 3: Is there any relationship between demographic factors and the use of technology in instructional practices?

Technology knowledge, as with other aspects of teacher knowledge, is not constant. It develops over time according to teachers' professional development or training, teaching

TABLE 8: Teachers' beliefs about technology and effect of demographic factors.

Teachers' beliefs about technology	Factors	Sum of squares	Mean square	*F*	*p* value	Effect size
Using technology to assess mathematics learning.	Age group	2.569	2.569	4.912	0.030	0.251
	Using curriculum	3.641	3.641	7.164	0.009	0.299
	Professional learning	5.141	5.141	10.541	0.002	0.355
Using technology helps with increasing learners' learning and understanding of statistics.	Age group	2.136	2.136	8.886	0.004	0.329
	Using curriculum	1.260	1.260	4.995	0.028	0.253
	Professional learning	1.102	1.102	4.328	0.041	0.237

TABLE 9: Factors associated with teachers' use of technology.

Factor	Teachers' practice	Mean square	*F*	*p* value	Effect size
Level of education	Drill and practice	29.501	32.686	0.000	**0.309**
	Demonstrate statistics principles	43.819	47.700	0.000	**0.395**
	Collect data using sensors or probes	19.069	24.034	0.000	**0.248**
	Retrieve or exchange data	26.244	31.960	0.000	**0.304**
	Solve and compute statistical problems	34.744	40.488	0.000	**0.357**
	Take a test or quiz	45.054	49.128	0.000	**0.402**
Quintile schools	Drill and practice	4.536	3.938	0.012	0.143
	Demonstrate statistics principles	8.384	6.944	0.000	**0.227**
	Collect data using sensors or probes	6.383	6.761	0.000	**0.222**
	Retrieve or exchange data	8.575	8.496	0.000	**0.264**
	Solve and compute statistical problems	3.681	2.588	0.060	0.099
Gender	Drill and practice	15.586	14.258	0.000	0.163
	Demonstrate statistics principles	22.461	18.544	0.000	**0.203**
	Collect data using sensors or probes	12.281	13.855	0.000	0.160
	Retrieve or exchange data	13.026	12.997	0.001	0.151
	Solve and compute statistical problems	15.586	13.909	0.000	0.160
	Take a test or quiz	25.818	21.869	0.000	**0.231**
Experience	Drill and practice	20.909	20.494	0.000	**0.219**
	Demonstrate statistics principles	21.780	17.844	0.000	0.196
	Collect data using sensors or probes	10.276	11.244	0.001	0.133
	Retrieve or exchange data	16.820	17.701	0.000	0.195
	Solve and compute statistical problems	13.176	11.421	0.001	0.135
	Take a test or quiz	12.500	9.171	0.003	0.112
Attended workshops	Drill and practice	7.738	6.445	0.013	0.081
	Demonstrate statistics principles	9.572	6.897	0.011	0.086
	Collect data using sensors or probes	4.485	4.516	0.037	0.058
	Retrieve or exchange data	7.848	7.313	0.009	0.091
	Solve and compute statistical problems	7.738	6.301	0.014	0.079
	Take a test or quiz	7.114	4.951	0.029	0.064

Note: Effect sizes between 0.2 and 0.4 (in bold) indicate that the difference between groups in terms of using technology has moderate practical significance.

experience as well as teachers' attainment of a higher level of education, and so on. The comparison of means (a standard test used to compare differences between means of two or more groups) was used to identify factors associated with teachers' tendency to integrate technology into their teaching practice as reported in Table 4. The teachers' demographic factors that were tested included school quintile, gender, age, teaching experiences, education level, workshop attendance, grades taught, level of education and instruction practices. The analysis reported in Table 9 was made by comparing the means at a significance level (*alpha*) equal to 0.05, between the variables that were explained in Table 4 and the demographic factors reported in Table 1.

The findings reveal that the difference between the means is statistically significant for the factors of gender, level of study, teaching experience, attending workshops and school quintile and their ability to integrate technology in different instructional practices at *alpha* equal to 0.05. Table 9 reports only significant effect *p*-values less than 0.05. It can also be noted from Table 9 that the effect sizes between 0.2 and 0.4 (in bold) indicate that the difference between groups in terms of using technology has moderate practical significance. On the other hand, it can be noted from Table 8 that the effect sizes less than 0.2 indicate that the difference between groups in terms of using technology has moderate practical significance (Kotrlik & Williams, 2003).

We also discuss the statistical relationship between some factors and the use of technology reported in Table 9 by examining which demographic group may be more likely to use technology in instructional practice than other groups. Regression analysis was made using mean plots to compare the magnitude of each group in terms of using technology; however, only those that reflected a moderate difference are reported.

We found that teachers who took postgraduate courses may be more likely to use technology than teachers who have a bachelor's degree or below. It can be noted from Figure 1 that means scores for teachers who attended postgraduate courses are greater in terms of taking a test or quiz, retrieving and exchanging data and demonstrating statistical principles than those with bachelor's degrees in terms of using technology (e.g. 2.230 versus 1.340 and 2.350 versus 1.510). This result was similar to findings in a previous study that education level contributes to teachers' use of technology in instructional practices (Mathews & Guarino, 2000).

The education department introduced a funding policy by using a system of categorising schools into five quintiles in order to inform decisions around financial allocations. Quintile 1 schools are those serving the poorest children while Quintile 5 schools cater for children who come from well-resourced backgrounds. Looking at Table 9, there also appears to be a statistically significant difference between teachers' school quintile and their ability to integrate technology in different instructional practices.

We observe from Figure 2 that teachers who teach in quintile 4 or 5 schools are more likely to use technology in instructional practices than teachers from the quintile 1–3 schools. A general trend in the use of technology as the quintile ranking of the school increased can be noted from Figure 3: as the quintile ranking of the school increases, the use of technology in the various instructional activities at that school increases.

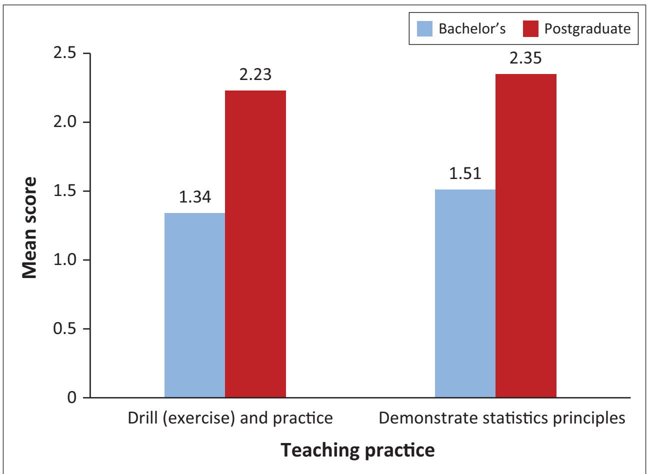

FIGURE 1: Using technology for instructional practice by level of education.

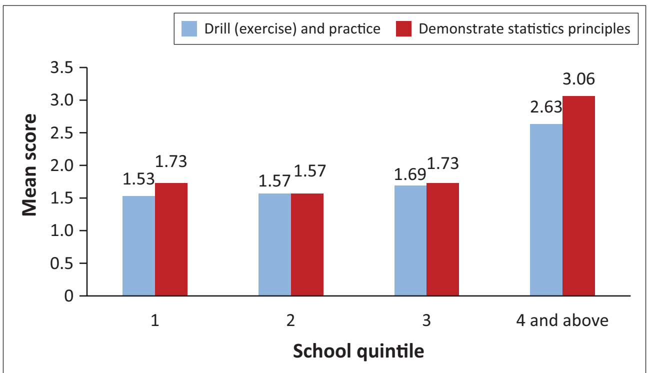

FIGURE 2: Using technology for instructional practice by school quintile.

Thus, mean scores for teachers who teach in quintile 4 and 5 are greater in terms of drilling and practice and demonstrating statistical principles than for those who teach in quintile 1, 2 and 3 schools in terms of using technology (e.g. 2.630 versus 1.690 or 1.570, 3.060 versus 1.750 or 1.570).

It is evident, therefore, that teachers who teach in the poorest schools are using technology to a lesser extent than those in the more well-resourced schools, which illustrates the digital divide between the poorest and the richest schools. However, it is important to note that teachers need more than access to use technology; they also need support in using the technology to teach more effectively. Ndlovu and Lawrence (2012) point out that it is not simply the availability of technology that brings about improvements in learning, but the ways in which this technology is used. Many studies have also reported that poorly resourced schools have less access to ICT facilities than well-resourced schools (Ndlovu & Lawrence, 2012), and the results of the current study also support such findings.

The findings further showed that male teachers are more likely to integrate technology into their educational practice than female teachers, given that the mean scores of male teachers were higher than those of female teachers (e.g. 2.500 versus 1.405, 0.921 versus 0.165, etc.). This finding supports results from a study in Africa (Buabeng-Andoh, 2012, p. 39), which explored factors that influence 'teachers' adoption and integration of information and communication technology'. His finding also showed that there was a significant difference between Ghanaian male and female teachers in technical ICT capabilities, where he found evidence that male teachers' scores were higher than those of female teachers in relation to the use of ICT in the classroom for instructional purposes.

Furthermore, it was noted that teachers whose teaching experience is 10 years or fewer were more likely to use technology than the teachers with teaching experience more than 10 years (e.g. 2.180 versus 1.250, 2.330 versus 1.400, etc.). This finding was also reported in another study (Almekhlafi & Almeqdadi, 2010), that is, that novice teachers are more likely to use technology and the internet in several teaching practices, which may be because they grew up in the technological era.

A statistically significant difference was also apparent between using technology in instructional practice and professional learning. This means that teachers who attended mathematical workshops may be more likely to use technology than those who did not (e.g. 2.148 versus 1.357, 1.967 versus 1.143, etc.). However, the effect sizes (Table 9) are small for all instructional practice. This means that the difference in terms of using technology between those who attended workshops and those who did not is small in practice. However, it appeared that the effect sizes (Table 9) are small for all instructional practice. This means that the difference in terms of using technology between those who attended workshops and those who did not is small in practice. Mueller et al. (2008) found that attending professional development workshops influences teachers' use of technology. Perhaps workshops that focus on the use and application of technology in the teaching of mathematics specifically may prove to have a bigger influence on whether teachers opt to use technology or not. Mueller et al. (2008) noted that 'professional development' and the 'continuing support of good practice' play a valuable role in sustaining the use of ICT in the classroom.

Conclusion

Digital classrooms to support students' learning have been the focus of research recently and this article reveals some of the challenges that schools in poorer communities in South Africa experience in this regard. Results from this study indicate that approximately a quarter of teachers have access to ICT for teaching mathematics. The use of ICT is even lower in the earlier grades (4–9), where only 10% of the teachers said they used ICT for teaching mathematics. Furthermore, the data showed that teachers are generally more comfortable with integrating calculators when teaching mathematics and statistics, as compared to using computers. This indicates that teachers may need training in the integration of computers into the teaching of mathematics and statistics in the classroom. Even though the practice of integrating technology into teaching instruction was not well developed among these teachers, they exhibited a positive view with respect to teaching using technology. Of interest is the finding that teachers who reported that they use the internet for instructional purposes held more positive views about the broad goals of mathematics and were also more confident about teaching mathematics than those teachers who did not. Beswick et al. (2012) assert that it is teachers' beliefs about general principles about the learning and teaching of mathematics that make a difference to student learning. This study suggests that teachers who have access to internet resources have progressive views about what the goals of mathematics and statistics should be. They also have stronger beliefs about the role of real-life applications in learning statistics and the need for connections across various subjects. The study also found that teachers who use the internet have higher levels of confidence in teaching mathematics. This may be because teachers who have access to a wider set of resources have a greater chance of learning more about the broad goals and applicability of mathematics beyond the confines of the classroom. Knowing more about the connections between mathematics and the real world helps people to better understand the role of fundamental concepts such as percentages, and this may in turn improve their confidence about teaching these concepts.

A problem that has been exposed is that although some schools are reported to have computers, these computers are not used in instructional practice, but are used for administrative purposes. It is not clear whether this is because teachers do not have the necessary skills or are reluctant to use the computers, or whether it is because school management is restricting the teachers' access to the technology. If computers are available but are not being used, the possible reasons for this state of affairs need to be urgently probed. Interventions that seek to increase access to technology will not be successful if the roll-out of computers does not result in a concomitant increase in the teachers' use of the technology. This study has provided evidence that teachers who attend workshops are more likely to use technology in their instructional practices than those who do not; hence, interventions that aim to increase the use of ICT in schools must be accompanied by continuous support. It is the support through workshops that will enable teachers to develop confidence in using technology and this may lead to more progressive attitudes by school management regarding the use of computers in classrooms. An important finding of the study is that teachers display different levels of technological readiness and enthusiasm according to their age, experience, gender and how well resourced their school is. Older teachers appear to need more support to help them become more confident to take on the technology.

Younger teachers are more confident and will not need as much support as their older counterparts. In addition, the study has also provided further evidence of the digital divide between schools with different quintile rankings. The digital divide presents a barrier to achieving equity in the provision of quality education to all learners. The removal of the digital divide requires more than just resources because it is the way in which the resources are used that makes the difference in the quality of the learning experience that is offered. The study shows that teachers from quintile 1 schools need much more sustained attention and support, different in form and substance from those from quintile 4 and above.

Successful integration of technology can have a transformative effect on schools and the education system as a whole. The study shows that teachers who have made a start at using the internet for their teaching have also developed broader understandings about the value and aim of teaching mathematics. Hence, helping teachers to take on technological resources is likely to assist them to develop new pedagogies that can help learners engage productively with the content of the subject. Continuous professional development will be required to help teachers integrate the newly acquired technological knowledge into their pedagogical knowledge so that they can develop in all the components specified in Mishra and Koehler's (2006) TPACK framework. In order for the DOE to realise their vision of helping their learners to function effectively in a knowledge society by using appropriate ICT in their schools (DOE, 2007), teachers need sustained support and assistance to develop the necessary ICT capabilities. Any intervention that involves provision of technological resources such as internet access, mobile tablets or laptops will need to be accompanied by the relevant teacher professional development training courses, as well as training and sustained support for using and maintaining the infrastructure.

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Competing interests

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Authors' contributions

O.U. performed the analysis of data and made a first draft of the manuscript. S.B. refined the draft. D.N. was responsible for checking the accuracy and suitability of the statistical analysis. O.U., S.B. and D.N. contributed to the conception of the study.

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