SOUTH AFRICA, TANZANIA AND FINLAND: MATHEMATICS TEACHER-STUDENTS' OPINIONS ABOUT INFORMATION AND COMMUNICATION TECHNOLOGY

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ABSTRACT

Low achievement in Mathematics at school level and during higher education remains a problem not only in South Africa but also worldwide. Information and

Communication Technology provides endless opportunities to enhance the teaching and learning of Mathematics. The purpose of this study is to determine and compare teacher-students' attitudes to Mathematics and ICT in order to plan for efficient, effective and appropriate methods in Mathematics education. A quantitative cross-sectional survey design, comprising a single mode research questionnaire, was distributed to groups of Mathematics teacher-students in South Africa, Tanzania and Finland. Descriptive statistical techniques, reliability and validity of the instrument scale, inferential statistics (ANOVA), and cross-tabulations were used and, where appropriate, effect sizes were calculated. A comparison of the perspectives revealed that the South African and Tanzanian teacher-students had a more positive perspective on ICT than the Finnish students. The teacher-students in the two African countries were also more willing to use ICT than the students in Finland, despite the latter's increased exposure and access to technology. Future research should be done to determine the appropriate types of technology to enhance teaching and learning as well as teacher-students' experiences regarding the use of technology in Mathematics education.

1. INTRODUCTION

Internationally and nationally, schools, colleges and universities face the problem of low achievement in Mathematics. Causes for concern are not only Mathematics results at school, but also those in teacher education. Teacher-students, especially those who study through distance education, do not have the time or resources to repeat their courses. This problem concerns students in both developed and developing countries.

2. PROBLEM STATEMENT

In the 2003, Trends in International Mathematics and Science Study (TIMSS), the third in a cycle of international Mathematics and Science assessments of Grade 8 learners, South Africa ranked last of the 46 participating nations, including some developing countries (Mullis, Martin, Gonzalez and Chrostowski 2003, 342). In South Africa, the Annual National Assessment (ANA) and the National Senior Certificate (NSC) examinations are essential for monitoring progress in achieving the targets for learner achievement. While in most cases, learners performed better in 2013 than in 2012, concern remains (DBE 2013, 31). Further, there were also apprehensions about the Grade 12 results, since one of government's targets in their Action Plan for 2014 was to increase the number who pass mathematics (DBE 2011, 8).

To compound this problem, many Mathematics teachers are not adequately qualified to teach in this subject area. According to the TIMSS Report, only 45 per cent of the Grade 8 learners are taught Mathematics by a fully certified teacher (Mullis et al. 2003, 342). The School of Continuing Teacher Education (SCTE) at a relatively large South African University was established in 2004 to contribute towards the improvement of education in South Africa (Van Zyl, Els and Blignaut 2013, 85). The SCTE, which expanded into a Unit for Open Distance Learning (UODL) in 2013, provides training and professional development to unqualified and under-qualified in-service teachers through open distance learning (ODL). Many teacher-students who enrol for studies at the SCTE do not pass their Mathematics modules, which leads to frustration when they have to repeat modules, pay additional class fees, or drop out of their studies. SCTE management envisioned the importance of technology enhanced learning (TEL) in ODL, and made vast advances in strategic planning and implementation of e-learning and research on the integration of TEL in the context of SCTE (Esterhuizen 2012, 123).

Teacher-students in Tanzania also work in challenging circumstances. Sutinen and Vesisenaho (2006, 266) report that the ICT used in Tanzania is far behind that used in Western countries. Although Finland is very successful with large scale studies, such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), only 23 per cent of Finnish Mathematics teachers reported weekly use of ICT in class (Ottestad 2010, 480).

Collaboration agreements between institutions of higher education (HEIs) in South Africa, Tanzania and Finland provided the means to explore the differences and similarities of the computer attitude of Mathematics students in South Africa with those of Mathematics students in a developing country, Tanzania, and a developed country, Finland.

The potential for digital technologies to enhance students' mathematics studies is widely recognised (Bennison and Goos 2010, 31). Scholars argue for the use of digital media in teaching as they believe that ICT adds value to the learning environment (Lantz-Andersson, Linderoth and Säljö 2009, 342). ICT provides students with fascinating, interesting, exciting and thought-provoking real-life challenges that can bridge the gap between Mathematics learnt at school and real-life Mathematics. ICT can improve on traditional teaching methods and allows teachers to create challenging learning environments in which learners' inventive potential could be fostered (Yushau, Mji and Wessels 2005, 20). Students should find it easier to understand tasks presented through the medium of ICT than in a traditional, verbal context (Lantz-Andersson et al. 2009, 327).

In order to use ICT effectively in the training of teachers and introduce teacher-students to ways in which they can use ICT in their classrooms, it is important to establish the teacher-students' perceptions about ICT. To attain a more global idea of these opinions, the main research question for this study was: What are the perceptions of Mathematics teacher-students enrolled for the ACE in Mathematics course regarding

ICT? This article focuses on how the perceptions of teacher-students in South Africa compared with those of students in a developing and a developed country, namely, Tanzania and Finland.

3. CONCEPTUAL FRAMEWORK

Mathematics education is a complex phenomenon that refers to, among other things, the philosophies, approaches and perceptions about the teaching and learning of Mathematics. Information and communication technology refers to the various technologies that are used to support and contribute to the process of learning, in this context, specifically the learning of Mathematics. While attitude can be defined as a learnt predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object (Fishbein and Ajzen 1975, 7), computer or ICT attitude and Mathematics attitude refer to feelings and emotions experienced while learning Mathematics using computers or ICT.

Distance learning promises flexible learning at the learners' convenience, which is why many students enrol for distance education. Technology plays an essential role in providing different options for both delivery and also pedagogy in distance education. Technology provides learners with access to education at any time and from any place (Beldarrain 2006, 139). Lecturers in distance education have many options to use new technologies such as wikis, blogs, podcasts, interactive whiteboards; open source technologies can increase real-time collaboration between students (Beldarrain 2006, 143). Teacher education should view technology as an essential aspect of teacher training for Mathematics and Science curricula. Teachers should be technologically literate to use technology in their practice. In teacher education programmes, computer-related courses and in-course practicals should provide teachers with the knowledge and skills necessary to integrate technology into their teaching (Pamuk and Peker 2009, 454).

Most developed and developing countries have established national ICT policies to increase the quality of education, provide work, empower and provide education (Tondeur, Van Braak and Valcke 2007, 963). Many governments in developing countries are initiating programmes to introduce computers into education. Developing countries have the responsibility to provide schools with computers and also to foster a culture of acceptance among those who are to use the tools (Albirini 2006, 386). The importance of teachers' computer attitude cannot be overlooked, hence the need for this study. To help prevent developing countries from falling even further behind in the information age, the governments of these countries should provide their citizens with the opportunities presented by ICT (Howie, Muller and Paterson 2005, 1).

The theoretical framework for this study was based on two related conceptual frameworks, namely, the Technological Pedagogical Content Knowledge (TPCK) model (Mishra and Koehler 2006) and the Four in Balance Model (Kennisnet 2009). Shulman (1987, 8) defines knowledge of teaching subject matter as pedagogical

content knowledge (PCK). It represents the blending of content and pedagogy into an understanding of how topics, problems or issues are organised, represented and adapted to the interests and abilities of the learners and presented for instruction. Mishra, and Koehler (2006, 1017) expanded on Shulman's work by capturing essential qualities of teacher knowledge required to integrate technology into teaching. They argue that thoughtful pedagogical use of technology requires the development of a complex form of knowledge that they call technological pedagogical content knowledge (TPCK). The components of content, pedagogy and technology are discussed separately, but also in pairs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and all three together, technological pedagogical content knowledge (TPCK).

The TPCK model posits that to develop good content, all three sources of knowledge: technology, pedagogy and content, should be thoughtfully interwoven (Mishra and Koehler 2006, 1029). TPCK is the integration of the development of subject matter with the development of knowledge of technology and of knowledge of teaching and learning. Quality teaching requires a fine understanding of the relationships between pedagogy, content and technology, and using this understanding to develop appropriate strategies and representations (Mishra and Koehler 2006, 1029).

TPCK should be a critical outcome of teacher education since it facilitates the process of technology integration to be open to analysis and development. The TPCK framework allows us to identify what is and is not important in discussions on teacher knowledge, particularly when using technology for teaching (Mishra and Koehler 2006, 1046) (Figure 1).
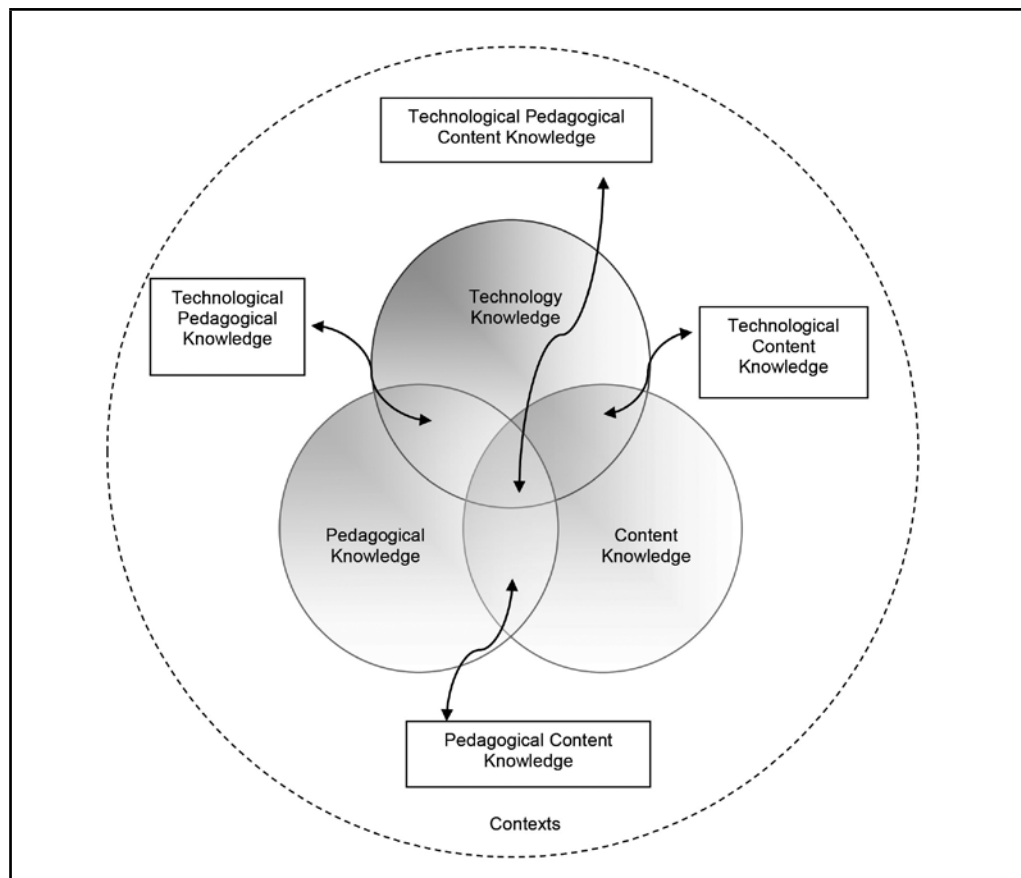
Figure 1:   Representation of Technological Pedagogical Content Knowledge

There is a need for new teachers to develop an overarching conception of their subject matter, particularly Mathematics and Science, with regard to technology and what it means to teach with technology (Niess 2005, 510).

'The Four in Balance Monitor' is an annual publication of the Kennisnet Foundation, which gives educators insight into the use and benefits of ICT in Dutch primary, secondary and vocational schools (Kennisnet 2009, 6). Kennisnet (2009, 7) is of the opinion that to benefit from ICT use, there needs to be a balance between: (1) vision, (2) expertise, (3) the digital learning materials utilised and (4) the ICT infrastructure available. In their opinion, it is only if these four conditions are in balance that ICT can offer real value. It is essential that teachers and school managers are positive about the possibilities and benefits of ICT. ICT is, therefore, deemed suitable for offering subject matter in multiple ways; weaker pupils make progress when learning with ICT and most pupils enjoy working with ICT.

Kennisnet (2009, 12) presents a discussion of the four basic elements: vision, expertise, digital learning materials and the ICT infrastructure. Vision is the school's view of what constitutes good teaching and how it aims to achieve it. The vision that the staff and manager adopt determines the school's policy, the design and organisation of its teaching. Expertise is the knowledge and skills that teachers and pupils use to achieve educational objectives. This involves not only basic ICT skills like operating a computer, but also pedagogical skills when ICT is integrated into the design of the learning processes. Digital learning materials encompass all digital educational content, formal and informal. Lastly, ICT infrastructure refers to the availability and quality of computers, networks and internet connections. Electronic learning environments and the management and maintenance of the school's ICT facilities are also embedded in this section. Individual teachers cannot create this structure on their own; support from the school's management is necessary (Figure 2).
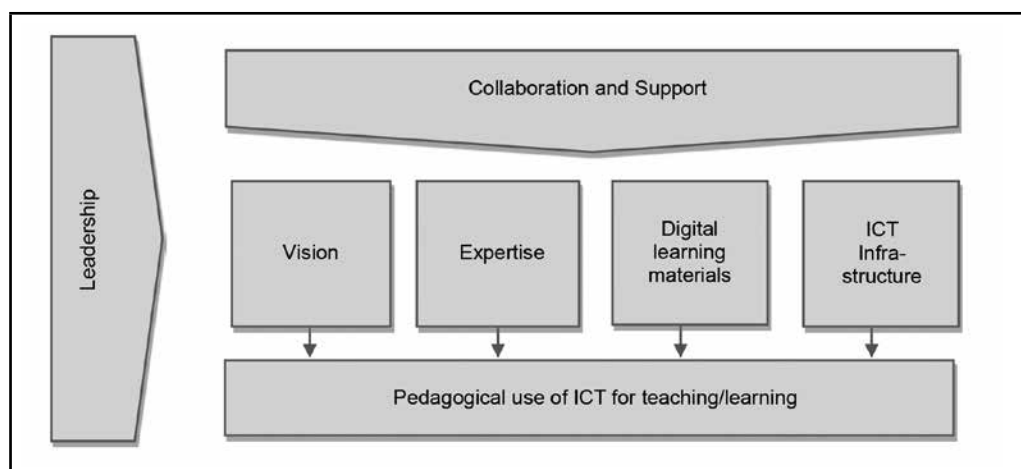

Figure 2:   Four in Balance Model (Kennisnet 2009)

Figure 3 illustrates how these two conceptual frameworks complement each other. The amalgamation of the three dimensions of technology knowledge, pedagogical knowledge and content knowledge can only be appreciated and effectively implemented if the leadership and the educator have sufficiently liberal and investigative vision to grasp these new ideas. Since vision refers to the school's view of what constitutes good teaching, the integration of these points could to a large extent be the means to achieve it by designing, organising and adapting the school's policy.

The integration of technology and content knowledge leads to knowledge about the relationship between technology and content. Teachers should have subject matter knowledge and knowledge of technology and should be able to integrate these two knowledge bases effectively. To make this blend meaningful and significant there needs to be an ICT structure in place: computers should be available and the quality of networks

and internet connections will determine the success with which ICT can be integrated into Mathematics education. The manner in which an institution's electronic learning environments are maintained and managed also plays an essential role in implementing ICT in Mathematics teaching.

Expertise has an influence on pedagogical and technological content knowledge. Expertise in Kennisnet's Four in Balance model refers to teachers and learners having sufficient skills and knowledge to use ICT in designing and organising learning processes to achieve educational objectives. Since pedagogical content knowledge goes beyond knowledge of the subject alone and accentuates subject knowledge for the purpose of teaching, the effect of expertise on this dimension of knowledge is obvious. Pedagogical content knowledge deals with expertise and knowledge of not only pedagogical techniques, but also students in the learning situation, their conceptions and misconceptions, their approaches and misapplication of prior knowledge. Figure 3 embodies an interpretation of how TPCK and the Four in Balance model could support each other.
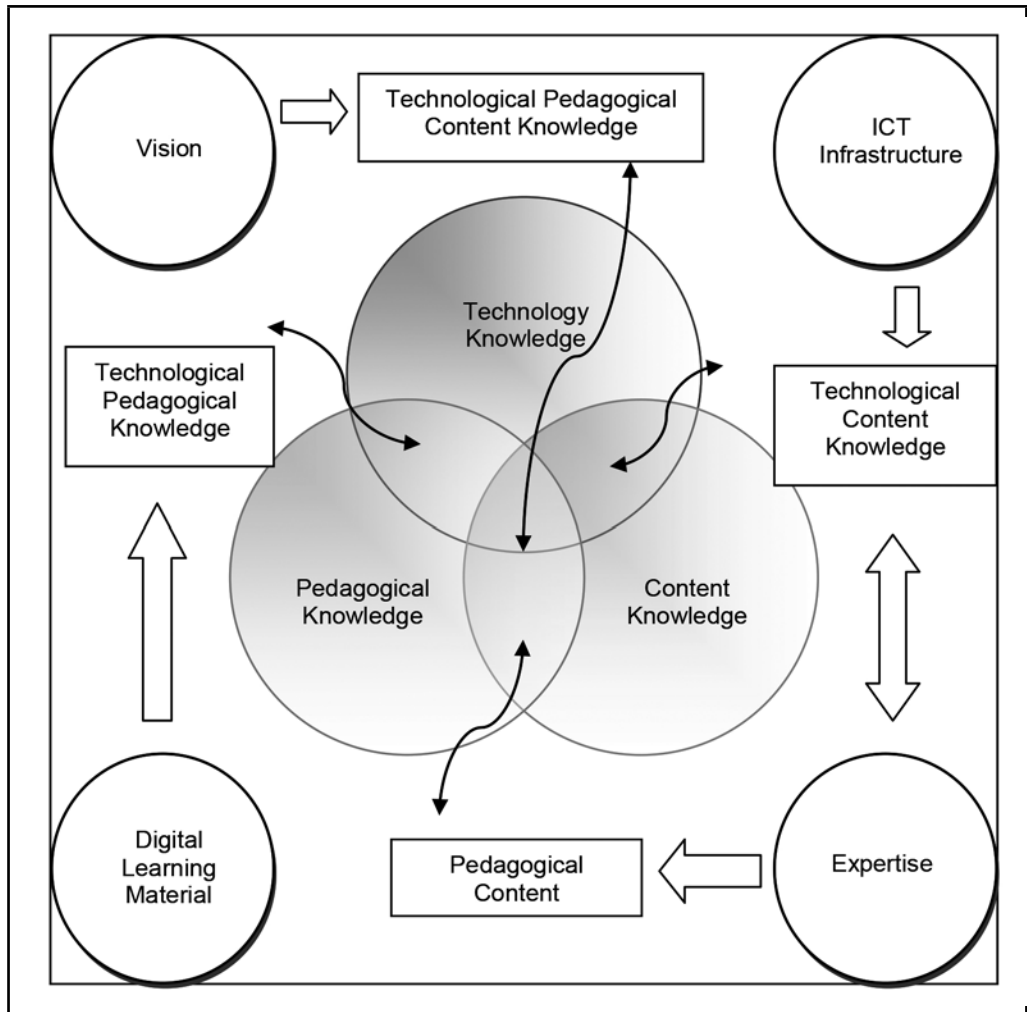
Figure 3: Representation of how the TPCK Model could be supported by the Four in Balance Model

Digital learning materials include all digital educational content (Kennisnet 2009, 12). The reason that it was linked to technological pedagogical knowledge in this study is that it is knowledge of the existence, components and capabilities of technologies in the teaching and learning climate. Knowledge of how to use these technologies to change teaching and learning is also essential.

4. RESEARCH DESIGN AND METHODOLOGY

The research stemmed from a radical-structuralist viewpoint. This paradigm is embedded in a materialist view of the natural and social world and primarily aims at providing a critique of the current situation in social matters. The notions that are central to the radical structuralist paradigm are totality, structure, contradiction and crisis (Burrell and Morgan 1994, 359).

4.1. Aim of the investigation

The aim of the investigation was to determine the attitude of teacher-students towards Mathematics and computers. The study stretches across three countries and compares the computer attitudes of teacher-students in South Africa with those of the teacher-students in Tanzania and Finland respectively.

4.2. Research strategy

The research followed a quantitative cross-sectional survey design comprising a single mode research questionnaire, presented to groups of Mathematics education students in three different countries.

4.3. Methods

The Loyd and Gressard (1984) Computer Attitude Survey (CAS) with additional questions was applied. No study could be found in South Africa that made use of the entire CAS, although some studies adapted it for their purposes (Thatcher 2008; Anthony, Clarke and Anderson 2000). Internationally the instrument has been used with numerous populations, including secondary school students, teachers, college students and adults, and was translated into Turkish and Hebrew (Francis, Katz and Jones 2000; Pamuk and Peker 2009). It appears that attitude domains are not culturally bound and language does not seem to play a role in the reliability of the instrument.

The questionnaire consists of a 30-item version of the CAS, rated on a five-point Likert type scale (strongly agree, agree, neutral, disagree and strongly disagree) (Loyd and Gressard 1984, 502). The higher the scores, the more positive the students' computer attitude. The questionnaire presents statements embodying attitudes towards computers and the use of computers divided as: (i) anxiety or fear of computers; (ii) liking of computers or enjoying working with computers; and (iii) confidence in the ability to use or learn about computers. Section A of the current instrument gleaned biographical detail of the participants and their willingness to spend time using computers at home and at work. Access to mobile phones and willingness to use computers and mobile devices were also determined. Section B has 30 CAS questions followed by 12 researcher

generated questions to attain contextual validity of students' attitudes to Mathematics and recent technologies.

4.4. Sampling

A cross-sectional survey design collected information from the entire population (Fraenkel and Wallen 2003, 397) of Mathematics teacher-students. They comprised all ACE Mathematics students at a large South African University (317 out of 920 returned the questionnaires), all Mathematics education teacher-students at a University College in Tanzania (111 out of 111 completed questionnaires), as well as all Mathematics education teacher-students from a University in Finland (59 out of 59 completed questionnaires).

4.5. Ethical aspects

Ethical principles were applied throughout the project: the participants were protected from any harm and the research data remained confidential at all times (Fraenkel and Wallen 2003, 57). Ethics consent was obtained from the Ethics Committee of the University as well as from all the related universities. Teacher-students completed letters of consent, ensuring their voluntary participation. Names were not required in the questionnaire and the identity of participants remained anonymous.

4.6. Trustworthiness: Validity, reliability

A factor analysis examined the construct validity of the instrument (Neuman 1997, 170). The factors revealed were: perseverance, insufficient computer or Mathematics confidence, computer or Mathematics anxiety, attitude to problem-solving with computers, self-perceptions about technology, computer confidence and Mathematics attitude. Internal reliability refers to the extent to which causal conclusions can be drawn. The Cronbach alpha coefficient measured the internal reliability based on inter-item correlations (Pietersen and Maree 2007, 216).

Table 1: Cronbach's Alpha Coefficient (Reliability)

Subscales	Loyd and Gressard (1984, 503)	Francis et al. (2000, 153)	Current Study 2010
Computer anxiety	0.86	Current Study 2010	0.60
Computer liking	0.91	0.88	0.555*
Computer confidence	0.91	0.85	0.85

Table 1 compares the Cronbach alpha reliability indices calculated for the scales of the CAS for the current investigation with the reliability indices Loyd and Gressard reported

in their original 1984 study, as well as with the reliability indices reported by Francis et al. (2000) in their study conducted in Hebrew. The current investigation reported a similar good internal consistency (reliability) for the Computer Confidence scale (Cronbach alpha 0.85). However, low reliability indices were found for the Computer Anxiety scale (0.6 Cronbach alpha coefficient) and the Computer Liking scale (Cronbach alpha value of 0.555). A possible reason for the unfavourable internal consistency of these scales is that English is a second or third language for the three participant groups. Van der Walt (1997) found that South African respondents would rather guess the answers to difficult statements than indicate that they did not understand the English terms. Reliability of the CAS can, therefore, be assumed for the study population of this investigation. Therefore, the results of the combined Computer Anxiety and Computer Liking scales were interpreted with caution.

4.7. Data collection procedures

The questionnaire was completed by student groups in South Africa, Tanzania and Finland. The researcher travelled to Tanzania to distribute and collect the questionnaires. The questionnaire was formatted for use on Survey Monkey, an online questionnaire tool used by some teacher-students in Finland. Others completed the paper-based version. The return rate for the questionnaires in Finland and Tanzania was 100 per cent. In South Africa the questionnaire was posted to the respondents with a return envelope included for return to the researcher. The return rate for the questionnaires in South Africa was 34.46 per cent (317 of 920).

4.8. Data processing

Inferential statistics addressed the comparison of the South African students' attitudes with those of students in Finland and Tanzania. With the aid of Statistical Package for Social Sciences (SPSS), the Statistical Services at the South African university calculated descriptive measures, reliability and validity of the instrument scale, inferential statistics (e.g. ANOVA), cross-tabulations and, where appropriate, effect sizes.

5. ANALYSIS AND DISCUSSION OF RESULTS

When comparing the three countries' responses in the categories of anxiety, liking and confidence, there were some notable similarities and differences. Regarding anxiety, the South African respondents seemed the least anxious about computers and Mathematics. This could be due to the fact that all teacher-students enrolled for the ACE course had some exposure to computers, regardless of whether they owned a computer or not, or due to the compulsory computer literacy module in their course. The statement *Computers do not scare me at all* and *I do not feel threatened when others talk about computers* have an over 80 per cent agree rate for the South Africans whereas the other

two countries were in the region of 60 per cent. Forty-five per cent of the respondents from Finland were neutral about feeling at ease in a computer class.

Concerning the negative indicators of computer anxiety, students from both African countries strongly disagreed with those statements; the Finnish respondents did not strongly disagree to the same extent. The responses of the South Africans in the category of Mathematics anxiety again very strongly indicated their lack of anxiety, the Tanzanians also indicated low levels of anxiety, but the Finnish respondents were more divided in their opinions. The respondents from Finland felt less comfortable working with a computer than the other two groups. Concerning the negative indicators of computer anxiety, respondents from the two African countries both strongly disagreed with those statements, while the Finnish respondents did not strongly disagree to the same extent. The South African and Tanzanian students had a disagree rate of 92.4 per cent and 93.6 per cent respectively for the statement *Computers make me feel uncomfortable* while the Finnish students only had a 55.9 per cent disagree rate.

The responses of the South Africans in the category of Mathematics anxiety again very strongly indicated their lack of anxiety, the Tanzanians also convincingly indicated low levels of anxiety, but the Finnish respondents were more divided in their opinions; some agreed to find Mathematics confusing (29.9%), some were neutral (36.8%) and some did not find it confusing (33.3%). In general it appeared that the teacher-students from Finland were more anxious about computers than the other groups, and that the South African teacher-students showed the lowest levels of anxiety of the three groups.

The second category was the liking of computers and Mathematics. The Finnish students indicated that they were less willing to use technology and liked computers less than the two African countries. The statement: *I think working with computers would be enjoyable and stimulating* had a 100 per cent disagree response rate in Finland compared to 96.8 per cent agree response in South Africa and 96.4 per cent agree response in Tanzania. The responses to the statement: *Once I start to work with a computer, I would find it hard to stop* also indicated that the Finnish group liked computers less than the two African groups. A similar tendency occurred with the category of Mathematics liking. Questions that referred to Mathematics liking were answered in a manner that indicated that the students in Finland liked Mathematics less than students in South Africa and Tanzania. A typical example of this tendency was the responses to the statement: *I enjoy trying to solve new Mathematics problems,* where the Finnish students' agree rate was 38.2 per cent, Tanzania 97.3 per cent and South Africa 94.6 per cent. The last component of liking was perseverance during computer use. The two African countries again indicated higher levels of perseverance than the Finnish students. The students from Finland clearly liked computers and Mathematics less than those in South Africa and Tanzania.

The confidence levels of the three groups followed a similar pattern. The computer confidence of the students in Finland was lower than that of the South Africans and Tanzanians. For the statement: *I am sure I could work with computers,* the Tanzanian

students had the highest agree rate at 98.2 per cent, the South Africans were second at 95.0 per cent and the Finnish had only a 64.3 per cent agree rate. *I could get good grades in a computer class* had similar responses: the African countries had a majority agree response, and the Finnish students were more neutral in their responses (55.9%). The self-confidence levels with regard to working with computers also clearly indicated that the Tanzanians showed the highest level of self-confidence (88.2%), followed by the South Africans (81.1%) and lastly the Finnish students (23.3%). The Finnish students also were not confident about doing advanced computer work and learning a computer language, whereas the other two groups were; they indicated confidence in pursuing a computer course. The South Africans indicated most convincingly that they would be able to deal with a computer course (76% agree). Generally, it appeared that the Tanzanians showed the most computer confidence, followed closely by the South Africans.

As with computer confidence, Mathematics confidence levels were highest in South Africa and Tanzania. All statements that indicated Mathematics confidence were answered such that the Finnish students showed the poorest confidence in Mathematics and the South Africans indicated the highest levels of confidence in Mathematics, with Tanzania following closely. An example of this was for the statement *Even when I battle with Maths I know I can solve the problem.* The South Africans and Tanzanians had a 94 per cent and 92 per cent agree rate respectively, where only 36 per cent of the Finnish agreed. Another indicator of confidence was attitude to problem solving with computers. Although the responses to the indicators in this category were slightly divided, the general impression was that the African countries again appeared to be more positive about problem solving with computers. The final category in the confidence scale was perceived ability with new technology. The students in Tanzania were most confident (81.0%), followed by the South African students (63.2%), and surprisingly 56.9 per cent of the students in Finland believed that they were good at using new technology. As with anxiety and liking, the same tendency occurred. The Finnish students were the least confident on all levels, followed by the Tanzanian students and the South African students, whose responses were very similar.

To indicate whether findings were practically significant, an effect size was calculated. When looking at mean differences, the effect size is denoted by *d*. The mean scores and the effect size for gender for the three different groups in relation to the nine identified factors were calculated. Gender had a medium effect, which tends towards a practically significant difference on the lack of confidence (d = 0.560), attitude to problem-solving with computers (d = 0.604), self-perceptions about technology (d = 0.763), computer confidence (d = 0.514) for Finland. There was a large effect on perseverance (d = 1.087) and fear of computers (d = 0.882) for the students in Finland. The effect sizes for the other two groups were not significant.

Ownership of a mobile phone in Tanzania had large practically significant differences on students' perseverance (d = 1.217), their attitude to problem solving with computers

(d = 1.504), their self-perceptions about technology (d = 1.543), their Mathematics attitude (d = 1.254) and their fear of computers (d = 0.946). It had a medium effect, which tends towards a practically significant difference, on their dislike of Mathematics or computers (d = 0.659).

For the group in South Africa mobile phone ownership only had a medium effect on anxiety (d = 0.642), and further no significant effect on any other factors. For the group of Finnish students, mobile phone ownership had a large practically significant difference on perseverance (d = 0.928), lack of confidence (d = 1.406), Mathematics attitude (d = 1.308), and dislike of Mathematics and computers (d = 1.195).

Having a computer at university had no significant effect on the factors identified for the South African students. It had a medium effect on the Tanzanians' perseverance and computer confidence and a large effect on their self-perceptions about technology. For the group in Finland, access to a computer at university had practically significant differences in their perseverance (d = 0.911), lack of confidence (d = 1.408), Mathematics attitude (d = 1.291), and their dislike of Mathematics or computers (d = 1.193).

Being willing to do Mathematics on a computer had large practically significant differences on the South Africans' lack of confidence (d = 1.294), anxiety (d = 1.007), computer confidence (d = 1.757) and fear of computers (d = 2.129). There was a medium effect on their perseverance (d = 0.761) and their attitude to problem-solving with computers (d = 0.778). For the Tanzanian students, there was a practically significant difference in their self-perceptions about technology (d = 1.017) and medium effects, which tend towards practically significant differences, on their attitude to problem-solving with computers (d = 0.570) and fear of computers (d = 0.723).

The Finnish students' willingness to do Mathematics on a computer showed practically significant differences in their perseverance (d = 0.839) and lack of confidence (d = 1.066), as well as medium effects, which tend towards practically significant differences, on their attitude to problem solving with computers (d = 0.603), computer confidence (d = 0.668), Mathematics attitude (d = 0.524) and dislike of Mathematics or computers (d = 0.551). Only the students in Finland indicated an effect of being willing to do Mathematics on a mobile phone. There were practically significant differences in their perseverance (d = 1.051), lack of confidence (d = 0.811) and computer confidence (d = 0.929). There were medium effects, which tend towards practically significant differences, in their attitude to problem solving with computers (d = 0.741) and their computer confidence (d = 0.929).

To determine if there were practical significant differences among the three groups of teacher-students, an analysis of variance was used (ANOVA). The *F*-values had corresponding *p*-values of 0.000 and since this value was less than 0.05, it meant that there were statistically significant differences among the means. This test does not indicate between which groups there are significant differences. To get that information, a post hoc test, the Tukey HSD (honestly significant difference) test was done. From the results of the test, it follows that with regard to perseverance, Tanzania and South

Africa were not significantly different from each other, but they were significantly different from Finland. When considering lack of confidence, the same results occurred. South Africa and Tanzania were not significantly different from each other, but they were different from Finland. This statistically confirmed the findings in the descriptive statistics, where the South African and Tanzanian teacher-students were found to be more confident in computers and Mathematics than the students in Finland.

The subscale of anxiety and attitude to problem solving with computers indicated that the Tanzanians and the Finnish were not significantly different from each other, but were significantly different from the South Africans. The South Africans were found to be the least anxious of the three groups. Where previously there was no clear difference between the groups regarding attitude to problem solving with computers, this analysis revealed that the South Africans again proved to be significantly different to the other two groups. The following four factors revealed the same differences, namely, self-perceptions about technology, computer confidence, Mathematics attitude and dislike of Mathematics or computers. The analysis proved that there was no significant difference between the two African countries, but they were significantly different from the Finnish students. The African teacher-students were more confident, had a more positive attitude towards Mathematics, had more positive self-perceptions about technology, and liked computers and Mathematics more than the students in Finland. The final factor, fear of computers, revealed that the South African group was significantly different to the other two groups.

Finland has been lauded much for its repeated success in PISA (Andrews, Ryve, Hemmi and Sayers 2014, 8), yet one must not lose sight of the fact that academic achievement in Mathematics is dependent on a variety of variables. Rivkin, Hanushek, and Kain (2005, 440) state that there can be very little doubt that teacher quality is an important determinant of both reading and Mathematical achievement in elementary schools; and of Mathematics achievement in Junior schools particularly. Added to that, Singh, Granville and Dika (2002, 324) did substantial research on the effect of motivation, interest and academic engagement as critical constructs of academic success. They found that all three of these factors are important when it comes to academic achievement in Mathematics and Science, but found that academic engagement (specifically the time students spent engaging with the subject) to be the most significant variable of the three in achieving academic success (Singh et al. 2002, 328). This could offer a possible reason why the Finnish teacher-students have a poorer attitude towards Mathematics and ICT, yet are able to achieve better academically.

Finnish teachers are required to hold a three-year bachelor's degree and a two-year Master's degree in the relevant subject to qualify to teach in primary and secondary schools (Niemi and Jakku-Sihvonen 2011, 33). In South Africa, although it is difficult to quantify, there are many unqualified or under-qualified teachers who are employed in permanent positions to teach in public schools. In a study that investigated factors that led to learners' poor performance in Tanzanian schools, it showed that the most

influencing factors on learner performance were: a lack of trained teachers, poor infrastructural facilities in schools, insufficient books in the library and frequent changes in the curriculum (Laddunuri 2012, 19). There are clearly vast differences in the qualifications required for teachers to teach in Finland and in Africa, and the resources that are available for them to use. This could be a further reason why Finnish students perform better in Mathematics, despite having a poorer attitude.

The combined conceptual framework that I suggest in this article highlights the importance of not only different knowledge bases for a teacher, but also expertise, an ICT infrastructure, vision and digital learning materials. If teacher-students have sufficient knowledge and expertise in Mathematics and ICT, but do not have a pertinent and sustained vision to use and implement that expertise, then it could lead to the significance of sensible and effective usage of ICT being undermined. On the other hand, if there is only a willingness to incorporate ICT in Maths education, yet the knowledge, expertise and infrastructure are lacking, the desired result will not be reached either.

6. IMPLICATIONS, RECOMMENDATIONS AND CONCLUSIONS

The computer and Mathematics anxiety of the teacher-students in Finland was the highest, and those of the teacher-students in Tanzania and South Africa were similar and were recorded as relatively low. The category of confidence also revealed that the Finnish teacher-students were not that confident and, of the two African countries, the Tanzanians appeared to be more confident with computers. The South African teacher-students were the most confident with Mathematics itself. The Finnish teacher-students' computer and Mathematics liking was recorded as the lowest and the teacher-students from the two African countries recorded relatively high. We can conclude that the teacher-students in the two African countries had a more positive attitude to computers and Mathematics, and were more willing to use ICT, than the students in Finland.

The combined conceptual framework emphasises seven aspects that play a crucial role in effective Mathematics education. It is essential that teachers not only have sufficient technological, pedagogical content knowledge, but educational institutions also require the necessary vision, a proper and effective ICT infrastructure, and expertise and digital learning materials to enhance meaningful learning in Mathematics. This model offers a wide range of variables to consider, each one vitally important to ensure effective Mathematics education. This is illustrated in the findings of the study.

The study indicated that South Africa and Tanzania registered low scores when it came to Mathematics and ICT anxiety, while Finnish teacher-students registered a neutral score here. The South African and Tanzanian teacher-students also indicated they liked Mathematics and ICT more than their Finnish counterparts, as well as having higher confidence levels when it came to Mathematics and ICT than their European colleagues. Despite this, the Finnish seem to be more effective when it comes to

Mathematics teaching, based on large-scale test results. This could be because their content knowledge, their pedagogical knowledge and their digital learning materials are superior to those of the African countries.

As the Four in Balance base model suggests, effective ICT integration also depends on collaboration, leadership and support − another area where the Finnish seem to be ahead of their African counterparts. The Finnish have policy in place and back this up with making resources available to their teachers and learners, something South Africa and Tanzania are lagging behind in. The African teacher-students are more willing and less fearful to embrace ICT and use it their classrooms, yet they do not seem to get the necessary support and resources, and they lag behind in expertise. This leads to less effective ICT integration, although their attitudes are positive and their willingness is clearly evident. The onus is on the leadership of African education to harness this willingness of their teacher-students to embrace ICT and guide them, as well as equip them, with the necessary resources and expertise in basic, secondary and tertiary education.

The importance of vision, another variable in the model, comes to the fore strongly. Part of vision will be the willingness to embrace ICT, both from teachers and management, as well as the foresight to realise the importance of ICT integration, specifically in Mathematics education, and strategically plan for this. One cannot lose sight of the importance of vision in this whole process, for if we consider something like support and collaboration, willingness and attitude definitely play a part here as well. Lack of willingness to collaborate and support endeavours in the integration of ICT in Mathematics education will certainly lead to less satisfactory results.

The question was posed in this study: What are the opinions of Mathematics teacher-students enrolled for the ACE in Mathematics course towards ICT? The answer is that, South African and Tanzanian students in particular are more than willing to embrace ICT in their own studies and in their classrooms. The powers that be should latch onto this and collaborate with their teacher-students, support them and equip them to meaningfully engage in the use of ICT in Mathematics education. This will, in turn, foster more effective Mathematics education. As the model shows, a positive attitude (vision) alone will not ensure this, but without a positive attitude it is bound to fail.

7. CONCLUSION

Thanks to the collaborative agreements between the South African university, the university college in Tanzania and the university in Finland, this research can be performed on a regular basis to establish what the current situation is in terms of students' attitudes towards ICT. It is important for the UODL (SCTE) to ascertain to what extent their students are willing to use ICT so that strategic planning can be done to incorporate the use of technology into the programmes that are presented. The research should also reveal exactly what type of technology the students would feel comfortable

with, and also what technology they have access to. Future research could determine teacher-students' experiences regarding the use of technology in Mathematics education and also establish which technology would be most suited to the teacher-students' needs and accessibility to technology. Teacher-students have a positive attitude towards ICT: education leadership should welcome this and strive towards using this positive attitude to enhance effective Mathematics education both at the level of professional development and in teaching practice.

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