 J Communication, 7(2): 266-273 (2016)

Exploring the Use of WhatsApp in Mathematics Learning: A Case Study

Jayaluxmi Naidoo[1] and Kabelo Joseph Kopung[2]

[1]Mathematics and Computer Science Cluster, School of Education, College of Humanities, University of KwaZulu-Natal, Private Bag X03, Ashwood, 3605, South Africa
Telephone: 031 260 1127, Mobile: 0744752938, Fax: 0866321410,
[2]Dumehlezi High School, Pinetown District, Department of Education
Cell: 0730631365, E-mail: [1]<naidooj2@ukzn.ac.za>, [2]<kkopung@gmail.com>

KEYWORDS Internet. Mobile Instant Messaging. Teaching. Technology. Resource. Smartphone

ABSTRACT This study reports on the use of the WhatsApp instant messaging as a resource for learning mathematics. WhatsApp is a smartphone messenger that employs the users' existing Internet data plan to connect the user to their learning community. This interpretive study employed a mixed method design. The participants for this study were 75 pre-service mathematics teachers enrolled for the Mathematics 110 module in one university in KwaZulu-Natal, South Africa. The data generated was analyzed using Activity Theory as a framework. The findings of the research suggest that the use of the WhatsApp instant messaging may assist students in learning mathematics. The use of WhatsApp instant messaging as a tool fostered a social constructivist environment for mathematical learning. This environment supported students in improving their performance in mathematics. Thus, within the domain of sustainable learning, this educational attainment is possible by designing and monitoring the e-learning milieu effectively.

INTRODUCTION

The use of communication technology within educational milieus could assist in sustaining the learning environment with a view of supporting students in attaining their learning goals (Yau et al. 2015). So too, the potential of mobile phones, particularly mobile instant messaging (MIM), to trigger broadened academic participation is increasingly acknowledged in research (Makoe 2010; Bere 2012; Rambe and Ng'ambi 2012; Rambe and Bere 2013; Rambe and Chipunza 2013; Naidoo 2015a). This is based on the capacity of MIM to create different spaces for student collaborative engagements in informal contexts, which may positively transform teaching and learning (Rambe and Bere 2013). However, the integration of MIM in classrooms and out of the classroom has often been confronted with academic resistance. Academic uncertainty about MIM is often established on its apparent distractive nature and probability to trigger off task behavior. However, research (Tour 2015) suggests that if technology based activities within an educational milieu are informed by ideas of sharing, collaboration and cooperation, then students may have more opportunities for learning. Thus, the current study focused on exploring the use of MIM (WhatsApp) as a tool for learning mathematics. The key questions being addressed in this study are:

- How does the use of WhatsApp influence the learning of mathematics?
- What does the use of WhatsApp instant messaging for pre-service teachers' learning of mathematics entail?

Address for correspondence:
Dr. Jayaluxmi Naidoo
Private Bag X03, Ashwood, 3605, South Africa
Telephone: 031 260 1127,
Mobile: 0744752938,
Fax: 0866321410,
E-mail: naidooj2@ukzn.ac.za

Mobile Phones in Education

The uptake of mobile phones by the South African population especially university students has increased over the past years (Benjamin 2011; Porter et al. 2015). As teenagers who rely on MIM as a communication tool enter Higher Education Institutions (HEIs), the use of mobile phones has become more established (Rambe and Chipunza 2013; West 2015). Moreover, since current teaching methods are increasingly

influenced by communication technologies (Trnova and Trna 2015), HEIs are strongly urged to accustom themselves with MIM so that they can adopt this as a responsive and innovative teaching and learning tool (Jeong 2007).

According to Echeverría et al. (2011), MIM presents multiple academic opportunities to both high school and tertiary students. However, it remains one of the least exploited functionalities of mobile devices both in schools and tertiary institutions (Rambe and Chipunza 2013; Naidoo 2015b). Some of the reasons for this limited exploitation include the perceived nature of text-based messages, limited academic conceptualization of how textual resources may be integrated into mainstream instructional practices, and uncertainties about the academic rigor of discussions generated via text messages (Rambe and Bere 2012).

Pre-service Teachers

Pre-service mathematics teachers in this study refer to students at Higher Education Institutes who are studying to become mathematics teachers. In South Africa, research (Spaull 2013) has indicated that many pre-service mathematics teachers have a substandard secondary school mathematics background. In addition, the difficulty in recruiting mathematically competent students into mathematics education implies that the majority of those who eventually enter into mathematics teacher education programs are those who would not have been accepted into other mathematically rigorous programs of study due to their low mathematics marks at school exit level (Pournara 2005). This produces mathematics teachers who maintain the cycle of mediocrity because some of their learners also join the teaching profession after completing their schooling (DoE 2010).

The implication is that a revolving door effect is established and maintained by this cycle. Additionally, often in teacher training institutions more emphasis is placed on pedagogical content knowledge at the expense of subject matter knowledge (Seaman et al. 2006; Benken and Brown 2008; Demirel 2015). Pedagogical content knowledge refers to knowledge that incorporates both the teacher's knowledge of content as well as the teacher being aware of strategies that would effectively demonstrate the nuances of this content (Shulman 1986). Moreover, teachers require knowledge of mathematics that is more extensive than what is being taught to students (Edwards et al. 2015). Additionally, within mathematics education the focus ought to be on mathematics proficiency and the effective teaching and learning of the abstract mathematics concepts (Naidoo 2014). However, research (Henry et al. 2015) indicates that pre-service teachers have a limited understanding of mathematics. Thus, mathematics proficiency for the majority of students in South Africa is still a distant dream (Moloi and Strauss 2005; Van der Walt and Maree 2007; Cohen and Seria 2014).

Mathematics Proficiency

Mathematics proficiency is described by Kilpatrick et al. (2011) in terms of five interwoven strands of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. The significance of being proficient in mathematics is well documented. Mathematics serves as a gateway to future professions in a variety of fields (Pandor 2006; Tella 2008). According to Tachie and Chireshe (2013), a thorough understanding of mathematics is an asset for applicants interested in obtaining better employment the world over. At its most basic level, mathematics is a requirement for science, computer technology, engineering, accounting and medical sciences (Tachie and Chireshe 2013; Stosic 2015). In recognition of the significance of mathematics outlined above, the South African government has made significant changes to the mathematics curriculum and mathematics education in an attempt to improve mathematics proficiency (DoE 2013).

Theoretical Framework

Activity theory was used as a framework for the study to account for the systems that link mathematics, students and the e-learning milieu. Based on the principles of activity theory, activity and learning are interactive and interdependent (Jonassen 2002). This theory is based on the assumption that all human actions are mediated by tools and cannot be separated from the social milieu in which an action is carried out. Activity theory in this study provides the framework for describing the structure, development and context for the activities that were support-

ed through the use of WhatsApp instant messaging. The relationships within the activity system that informed the analysis of this study were interrogated using the second generation activity theory as proposed by Engeström (1987).

Within this perspective, mobile technology is not perceived as the object of learning but as a tool to support students' learning activities and mobile devices are viewed as the mediators of learning (Bødker and Petersen 2000; Uden 2007). Identifying the tool in an activity is crucial for representing the activity system (Hardman 2015). Thus, within this study when answering the first research question for how the use of WhatsApp influences the learning of mathematics, the WhatsApp instant messaging tool was viewed as the mediating device for learning. The use of this mediating device was explored to see whether or not the tool influenced the learning of mathematics. Consequently, this exploration enabled the researcher to develop a more supportive learning environment as well as to interpret students' experiences within these situations easily (Kuutti 1996). Only through the acknowledgement of the distributed nature of knowing, can meaningful learning contexts be fostered (Uden 2007). Thus, knowing and learning are perspectives of an activity system and not necessarily those of individuals.

Collaborative learning using mobile technology is situated within and between activities (Uden 2007). An activity can also be conceived as a system of distributed cognition (Hutchins 1996) whereby individuals collectively work towards a common goal (Weick and Roberts 1993). Therefore, the division of labor plays a significant role in the development of a common goal (Stein and Zwass 1995). Thus, within this study to respond to the second research question on the use of WhatsApp instant messaging for preservice teachers' learning of mathematics entail, the division of labor within this activity system was explored.

Another benefit of applying activity theory to mobile collaborative learning is concerned with the interface of the application (Uden 2007). The interface of the mobile learning device is in constant development, changing the appearance as the user and context develops (Jonassen and Rohrer-Murphy 1999). Context awareness plays a crucial role in reducing the user's explicit input and activity theory enables one to interpret the context of user behavior in the application and to minimize explicit input, since this would allow one to provide better usability for mobile learners (Uden 2007). Thus, understanding a phenomenon means knowing how it is developed into its existing form and this applies to all the elements of an activity (Kaptelinin 1996). Thus, the current relationship between subject and object includes aspects pertaining to the development of that relationship (Kuutti 1996).

METHODOLOGY

The purpose of this mixed methods design study was to employ an interpretive approach to explore the use of the WhatsApp instant messaging (WIM) in the learning of mathematics. The pre-service mathematics teachers who were selected as participants were registered for the Mathematics 110 module. This is a foundational module at the participating university that is generally offered to pre-service Further Education and Training (FET) mathematics students in their first year of study. The purpose of this module is to prepare pre-service teachers to effectively facilitate the teaching and learning of mathematics in the FET phase.

Gatekeeper access was obtained from the participating university. Subsequently, each participant was provided with an informed consent form, with information describing the process the research would follow. Additionally, each participant was informed of his or her right to withdraw at any time from the study without fear of prejudice. A pilot study was conducted with a sample of 5 students to ensure the validity and reliability of each research instrument. For the main study, quantitative data was obtained through the use of a mathematical proficiency questionnaire while qualitative data was obtained through the use of a semi-structured interview schedule.

The Mathematical Proficiency Questionnaire

The mathematical proficiency questionnaire (MPQ) was based on FET mathematics content. The questionnaire contained a variety of mathematical problems based on Algebra, Trigonometry and Euclidean Geometry. Each participant was required to complete a pre and post intervention MPQ. The intervention in this study was the tutoring of students through the use of the WIM. The mathematical proficiency question-

naire was a pen and paper questionnaire consisting of nine questions totaling 60 marks. Each question was allocated marks depending on the level of difficulty and the amount of information required. The time limit for the answering of each questionnaire was 90 minutes. The MPQ measured the potential of a participant to cope with mathematics as well as the participant's mathematical ability.

The Interview

Qualitative data was collected through a seven-question semi-structured interview schedule. The interview schedule was revised once the quantitative data was analyzed. The interview questions were divided into three major sections for views and perceptions about learning mathematics through the use of WhatsApp instant messaging, successes and challenges of learning mathematics while using the WhatsApp instant messaging, and reflections and general comments regarding the study.

Questions that focused on participants' views and perceptions about learning mathematics through the use of the WhatsApp instant messaging were geared toward understanding how participants viewed mathematics learning using the WhatsApp instant messaging. The sections relating to the success and challenges of learning mathematics using the WhatsApp instant messaging aimed at investigating what and how respondents benefited in this project, and what challenges had been encountered. The interviews lasted approximately 40 to 60 minutes and took place at a coffee shop at the university concerned. All interviews were audio recorded with each participant's permission.

Data Analysis

The quantitative data was analyzed using a statistical test (paired t-test with dependent groups). The paired t-test is suitable in situations where the participants from the same group are assessed twice as in a pre and post intervention study (McMillan and Schumacher 2010). The paired t-test assumes that subjects from one group are divided into two groups based on categorical variables (male and female) and continuous variables (marks from the questionnaires) (Cohen et al. 2011). Within the quantitative phase of the study, the data producing questions focused on pre-service teachers learning of mathematics through the use of WIM.

This was then followed by semi-structured interviews of purposefully selected participants. Six participants were selected based on their level of performance in both the pre- and post- intervention mathematical proficiency questionnaires. That is, two from level 1 (excellent performance), two from level 2 (moderate performance) and two from level 3 (inadequate performance) were selected. In this phase, the data producing questions addressed both internal and external factors that could have contributed to the differences in scores of individual participants on the two MPQs.

The qualitative data was analyzed using thematic coding. Coding of the data consisted of looking at the content of the responses elicited from each participant and arranging them in terms of frequency or repetition. A thematic analysis followed, which analyzed all components in each participant's interview to form a comprehensive picture of their collective experiences. Once patterns were established, they were developed into themes.

RESULTS AND DISCUSSION

This study explored the use of WhatsApp instant messaging (WIM) for pre-service teachers' learning of mathematics. For this purpose, the study employed a mixed methods approach where both quantitative and qualitative data were used to answer research questions. The study was guided by the following research questions:

- How does the use of WhatsApp influence the learning of mathematics?
- What does the use of WhatsApp instant messaging for pre-service teachers' learning of mathematics entail?

Statistical methods were utilized in order to analyze the pre-intervention MPQ and the post-intervention MPQ scores for the experimental and control groups. The statistical analysis of data revealed a moderate correlation of 0.328 between the pre-service teachers who used WhatsApp instant messaging for mathematics learning (experimental group) and those who did not (control group). There was also a statistically significant difference between performance in the pre-intervention MPQ and performance in the post-intervention MPQ of the experimental group and a highly significant difference be-

tween the post-intervention MPQ scores of the control group when compared to the post-intervention MPQ scores of the experimental group.

The above statistical results reveal that using WhatsApp instant messaging for mathematics learning was instrumental in improving mathematics performance in the MPQs. Also, since there was a highly significant difference between the post-intervention MPQ scores in the experimental group and those of the control group, it indicates a statistically significant higher gain from pre-intervention MPQ to post-intervention MPQ. It can be deduced that the improvement of the performance in mathematics from pre-intervention MPQ to post-intervention MPQ was not due to chance but rather could be due to the use of the WhatsApp instant messaging for learning mathematics. This tool offered pre-service teachers an opportunity to engage in meaningful mathematical interactions, hence improving mathematical learning.

In order to answer the question revolving around the use of the WhatsApp instant messaging in pre-service teachers' learning of mathematics, semi-structured interviews of purposefully selected pre-service teachers were used to produce data. The qualitative data was analyzed using thematic coding. The following themes emerged for academic networking, collaborative engagement, positive freedom, transformation of pedagogy, and increased participation.

Academic networking meant that WhatsApp instant messaging was utilized by pre-service teachers as a communication and transactional tool to learn mathematics. This is evident in the transcripts that follow.

Gamo: *"…I learn by explaining to others what I know and I like receiving feedback from classmates. I live at a distance of about 45 km away from the campus, so getting involved in group discussions after hours is practically impossible… WhatsApp instant messaging made it easy for me to engage in group discussions after hours because I could academically interact with my classmates at any time of the day, regardless of my location …"*

Moh: *"…The beauty of WhatsApp instant Messaging is that it is an application that runs on a portable mobile device, therefore, my mathematics learning is not limited to one place. Since messages can be read anywhere, even in restricted areas such banks and hospitals, portability of these devices leads to flexibility in learning…"*

As is evident, the use of WhatsApp instant messaging allowed participants to communicate regardless of their location. Participants could engage with the learning of mathematics at their own pace and in their own time. Additionally, research (Relojo and Pilao 2016) suggests that one ought to take advantage of networking platforms, as this assists in creating significant and stable collaborative affiliations.

Collaborative engagement implied that pre-service teachers used WhatsApp instant messaging to advise others on how to solve mathematical problems. These sentiments are represented in the transcripts that follow.

Sbo: *"…I do not stay in campus or close to any of my classmates, so I do not have anyone to consult after hours and I ended up studying alone. WhatsApp instant messaging made it easy for me to engage in collaborative learning since I could interact anytime with my classmates…"*

Gundi: *"…the WhatsApp instant messaging made me realize the worth of my classmates. Contributions they made significantly contributed to my knowledge of mathematics. I learnt a lot of mathematical concepts and problem-solving strategies from my classmates…"*

Bhaka: *"…WhatsApp instant messaging enabled me to draw from diverse ideas and viewpoints of my classmates without the need of going through large amount of text…"*

The division of labor within this activity system was explored. Based on an analysis of this exploration, the need for a collaborative learning environment was revealed. The use of Activity Theory as a theoretical framework exhibited that in order to improve student performance in mathematics, students ought to participate actively and collaboratively with each other. Along similar lines, research (Ataie et al. 2015) suggests that collaborative learning could help students improve their responsiveness and critical thinking.

Positive freedom inferred that WhatsApp instant messaging supported mathematics knowledge sharing and also bridged the physical and information divide among pre-service teachers. Notions of positive freedom are reflected in the transcripts that follow.

Bhaka: *"…I can scroll down and browse through…at any place, because I can carry my*

phone around. I even get to use WhatsApp instant messaging for academic purposes… therefore portability makes learning accessible anywhere, which is a good idea…"

Moh: *"…Learning is no longer limited to a classroom. The WhatsApp instant messaging made it possible for me to study whenever I feel like studying. My classmates were always available to assist me with my learning, regardless of the location…"*

Thus, the use of WhatsApp messaging ensured that learning became a practice of freedom (Specia and Osman 2015), which required all participants to engage in learning regardless of where they were. This freedom encouraged students to actively participate in the learning of mathematics.

Moreover, transformation of pedagogy meant that the use of WhatsApp instant messaging in mathematics learning fostered a social constructivist environment for tutor-student and peer-based co-construction of mathematical learning. The tutor's role was transformed from an instructor to that of a facilitator and mentor who provided guidance on demand. Pre-service teachers' roles were also transformed from information receivers to information generators and collaborators. Additionally, research (Dole et al. 2015) proposes that students obtain and remember knowledge when they are engaged in their learning.

Increased participation meant that WhatsApp instant messaging's anonymous collaborative learning allowed shy and less confident pre-service teachers to engage more productively and to become more vocal through information seeking, critical questioning and information sharing practices. This is evident in the transcripts that follow.

Gamo: *"…I can ask questions at my convenience and get peer feedback in a short space of time. I have improved my problem solving skills while responding to peer questions. I feel that I have learnt a lot through WhatsApp instant messaging…"*

Manku: *"…I can access academic material in various formats that include, but is not limited to, images, audio, videos and text, which fosters my mathematics learning. Provision of learning material in various formats captured my attention, and subsequently motivated me to be involved in learning…"*

Manku: *"…I am a shy person and I do not feel comfortable participating in a face-to-face environment… Now I can comfortably participate in academic discussions without fear of victimization from my classmates, since no one would know that it is my contribution…"*

Building student confidence when confidence is low is important for academic success (Atherton 2015) and this was achieved in this study through the use of WhatsApp instant messaging. These excerpts are also supported by current research (Trnova and Trna 2015), which proposes that communication technology serves as a motivational factor, which stimulates active participation by students. Along similar lines, Yau et al. (2015) maintain that the use of communication technology may assist students in attaining the learning goals. Additionally, Tour (2015) suggests that the use of technology-based activities within an educational milieu increases opportunities for students to learn. In this study, students performed at a higher level, were more actively engaged with content and were motivated and confident in the lecture room. These positive factors may have been achieved by the use of WhatsApp instant messaging, since this was the only additional aspect introduced to the students amid the pre and post intervention task.

CONCLUSION

The first key research question addressed in this study was: *How does the use of WhatsApp influence the learning of mathematics?* The findings reveal that while the use of the WhatsApp instant messaging was innovative and successful within this study, both advantages and disadvantages of WhatsApp instant messaging were uncovered.

The WhatsApp instant messaging afforded the following advantages to both the tutor and pre-service teachers of technical advantages such as simplicity and availability. The educational advantages were that mathematics learning occurred anywhere and at any time, students had the opportunity to correct mistakes immediately, and this tool provided a secure learning environment, and in addition, assisted students in improving their academic performance.

While the advantages of using WhatsApp instant messaging have been discussed above, WhatsApp instant messaging posed a challenge with short messages. Given that a single-text message is limited to 140 characters, participants were challenged by the short message length and succinctness of language required. Moreover, there was a challenge of WhatsApp in-

stant messaging's lack of mathematical symbols. This led to pre-service teachers' being limited when trying to ask or respond to their peer's question or completely avoiding some questions because it would be difficult to write them on WhatsApp instant messaging. Finally, there was a challenge of divided attention. When participants responded to the arrival tone of new text messages, their attention was drawn away from the task in which they were engaged. This was a significant distraction when text messaging was used within the educational milieu.

In response to the second research question: *What does the use of WhatsApp instant messaging for pre-service teachers' learning of mathematics entail?* The study revealed that in order for students and the tutor to use the WhatsApp instant messaging tool, all participants were required to be knowledgeable about the use of this tool. The WhatsApp instant messaging tool had to be used frequently by all participants in order to achieve positive results. Participants had to be respectful when responding as well as participants had to be available to actively participate on the group chats to ensure maximum learning.

RECOMMENDATIONS

The use of innovative strategies to ensure the effective learning of mathematics is essential in contributing to sustainable learning. It is recommended that the use of the WhatsApp instant messaging (WIM) be implemented within other modules in Higher Education to ensure that students' needs and interest are catered for.

ACKNOWLEDGEMENTS

The authors would like to thank the University of KwaZulu-Natal's Teaching and Learning office for partially funding this research (UTLO: TLCRG 13). The opinions expressed here are those of the authors and do not necessarily reflect the position, policies or endorsements of the university.

REFERENCES

Ataie F, Shah A, Nazir MNM 2015. Collaborative learning, using Facebook's page and groups. *International Journal of Computer System*, 2: 47-52.

Atherton M 2015. Measuring confidence levels of male and female students in open access enabling courses. *Issues in Educational Research*, 25: 81-98.

Benjamin C 2011. SA Leads Way in Mobile Marketing. From <http://www.businessday.co.za/articles/ Content. aspx? Id=134236> (Retrieved on 1 March 2014).

Benken BM, Brown N 2008. Integrating teacher candidates' conceptions of mathematics teaching and learning: A cross university collaboration. *The Journal of Higher Education*, 6: 132-1145.

Bere A 2012. A Comparative Study of Student Experiences of Ubiquitous Learning Via Mobile Devices and Learner Management Systems at a South African University. *Proceedings of the 14th Annual Conference on World Wide Web Applications*, Durban, South Africa, 7-9 November 2012.

Bødker S, Petersen MG 2000. Design for learning in use. *Scandinavian Journal of Information Systems*, 12: 61-80.

Cohen L, Manion L, Morrison K 2011. *Research Methods in Education*. London: Routledge.

Cohen M, Seria N 2014. South Africa Struggles to Fix Dysfunctional Schools. From <http:// www. bloomberg. com/ apps/ news? pid = news archive and sid = aec HuD7bb5Pw> (Retrieved on 5 June 2014).

Department of Education 2010. *National Strategy for Mathematics, Science and Technology Education: Creating Tomorrow's Stars Today. Implementation Plan 2011-2015*. Pretoria: Government Printer.

Department of Education 2013. *National Education Policy Act: The National Policy Framework for Teacher Education and Development in South Africa*. Pretoria.

Demirel HH 2015. *Digital Lessons for Enhancing Communicative Skills: A Handbook for Turkish EFL Teachers*. Master's Project. Paper 213. San Francisco, USA.

Dole S, Bloom L, Kowalske K 2015. Transforming pedagogy: Changing perspectives from teacher-centered to learner-centered. *Interdisciplinary Journal of Problem-Based Learning*, 10: 1-15.

Echeverría A, Nussbaum M, Calderón JF, Bravo C, Infante C, Vásquez A 2011. Face-to-face collaborative learning supported by mobile phones. *Interactive Learning Environments*, 19: 351–363.

Edwards R, Hyde R, O'Connor M, Oldham J 2015. The Importance of Subject Knowledge for Mathematics Teaching: An Analysis of Feedback from Subject Knowledge Enhancement Courses. *Paper Presented at the British Society for Research into Learning Mathematics*. Reading University, Berkshire, UK, 7 November.

Engeström Y 1987. *Learning by Expanding: An Activity-theoretical Approach to Developmental Research*. Helsinki: Orienta-Konsuit.

Hardman J 2015. Pedagogical variation with computers in mathematics classrooms: A cultural historical activity theory analysis. *Psychology in Society*, 48: 47-76.

Henry DL, Baltes B, Nistor N 2015. Social mobility through mathematics proficiency for English language learners. *Journal of Social Change*, 7: 94-102.

Jeong W 2007. Instant messaging in on-site and online classes in higher education. *EDUCAUSE Quarterly*, 30: 30-36.

Jonassen DH 2002. Learning as activity. *Educational Technology*, 42: 45-51.

Jonassen DH, Rohrer-Murphy L 1999. Activity theory as a framework for designing constructivist learn-

ing environments. *Educational Technology Research and Development*, 47: 61-79.
Kaptelinin V 1996. Computer mediated activity: Functional organs in social and developmental contexts. In: BA Nardi (Ed.): *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Cambridge, MA: MIT Press, pp. 227-253.
Kilpatrick J, Swafford J, Findell B (Eds.) 2011. *Adding It Up: Helping Children Learn Mathematics*. Washington, DC: National Academy Press.
Kuutti K 1996. Activity theory as a potential framework for human-computer interaction research. In BA Nardi (Ed.): *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Cambridge, MA: MIT Press, pp. 17-44.
Makoe M 2010. Exploring the use of MXit: A cell phone social network to facilitate learning in distance education, open learning. *The Journal of Open, Distance and e-Learning*, 25: 251-257.
McMillan JH, Schumacher S 2010. *Research in Education: Evidence-based Inquiry*. New York, NY: Pearson.
Moloi M, Strauss J 2005. *The SACMEQ II Project in South Africa: A Study of the Considerations of Schooling and the Quality of Education*. Harare, Zimbabwe: SA CMEQ.
Naidoo J 2014. Responsive and innovative pedagogies: Exploring postgraduate students'insights into the use of technology in mathematics teaching. *Alternation*, 12: 99-123.
Naidoo J 2015a. Exploring the Use of Teaching and Learning Technologies in Higher Education: A Case Study of One University. *Paper Presented at the 9th Annual University Teaching and Learning Higher Education Conference*. Southen Sun Elangeni Hotel, Durban, South Africa, 21-23 September.
Naidoo J 2015b. The use of technology based tools in mathematics teaching at one university in South Africa. *International Journal of Educational Sciences*, 10: 410-418.
Pandor N 2006. Not Yet Where We Want To Be. *Address by the Minister of Education on the release of the 2006 Senior Certificate Examination Results*. Cape Town: Parliament, 26 December 2006.
Porter G, Hampshire K, Lake L, De Lannoy A, Cornell V 2015. *Mobile Phones and Education in South Africa: Emerging Evidence and Recommendations*. Cape Town, South Africa: Children's Institute, University of Cape Town and Durham University.
Pournara C 2005. The Glass is Half-full: Rising to the Challenge of Pre- service Mathematics Teacher Education in South Africa. *Paper Presented at the 15th ICMI Study Conference in the Professional Education and Development of Teachers of Mathematics*. University of Witwatersrand, Johannesburg, South Africa, 22-25 June.
Rambe P, Bere A 2012. An M-Learning Strategy for Leveraging Learner Participation: Using Whatsapp Mobile Messaging at a South African University of Technology. *Paper Presented at Southern African Computer Science Lecturers Association Conference (SACLA)*, Black Mountain Leisure and Conference Hotel, Thaba Nchu, 1-3 July.
Rambe P, Chipunza C 2013. Using Mobile Devices to Leverage Student Access to Collaboratively-Generated Re-sources: A Case of WhatsApp Instant Messaging at a South African University. *Paper presented at the International Conference on Advanced Information and Communication Technology for Education (ICAICTE 2013)*, Crete, Greece, 20-22 September.
Rambe P, Ng'ambi D 2012. Using Ubiquitous Technologies to Cognitively Scaffold Academically Underprepared Learners: Student Contextualized Learning in Mobile Learning Environments. *Paper Presented at the IADIS International Conference on Internet Technologies and Society (ITS 2012)*, Vienna, Austria, 27-28 June.
Relojo D, Pilao SJ 2016. Key contributions and future directions of academic social networking services for the digital academic. *International Journal of Humanities and Social Science Studies*, 2: 94-101.
Seaman CE, Szydlik SD, Szydlik JE, Beam JE 2006. A comparison of pre-service elementary teachers' beliefs about mathematics and teaching mathematics. *Journal of Science and Mathematics*, 105: 179-210.
Shulman L 1986. Paradigms and research programs in the study of teaching: A contemporary perspective. In: M Wittrock (Ed.): *Handbook of Research on Teaching*. New York: Macmillan, pp. 1-36.
Spaull N 2013. A Preliminary Analysis of SACMEQ III South Africa, *Working Papers* 11/11, Department of Economics, Stellenbosch University, Stellenbosch.
Specia A, Osman AA 2015. Education as a practice of freedom: Reflections on bell hooks. *Journal of Education and Practice*, 6: 195-199.
Stein EW, Zwass V 1995. Analysing organisational memory with information systems. *Information Systems Research*, 6: 85-117.
Stosic L 2015. The importance of educational technology in teaching. *International Journal of Cognitive Research in Science, Engineering and Education*, 3: 111-114.
Tachie SA, Chireshe R 2013. High failure rate in mathematics examinations in rural senior secondary schools in Mthatha District, Eastern Cape: Learners' attributions. *Stud Tribals*, 11: 67-73.
Tella A 2008. Teacher variables as predictors of academic achievement of primary school pupils mathematics. *International Electronic Journal of Elementary Education*, 1: 17-33.
Tour E 2015. Digital mind-sets: Teachers' technology use in personal life and teaching. *Language Learning and Technology*, 19: 124-139.
Trnova E, Trna J 2015. Motivational effect of communication technologies in connectivist science education. *Online Journal of Communication and Media Technologies*, 5: 107-119.
Uden L 2007. Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation*, 1: 81-102.
Van der Walt M, Maree K 2007. Do mathematics facilitators implement metacognitive strategies? *South African Journal of Education*, 27: 223-241.
Weick KE, Roberts KH 1993. Collective mind in organisation. *Administrative Science Quarterly*, 8: 357-381.
West DM 2015. *Connected Learning: How Mobile Technology Can Improve Education*. Washington, DC: The Brookings Institution.
Yau HK, Cheng AL, Ho WM 2015. Identify the motivational factors to affect the Higher Education students to learn using technology *The Turkish Online Journal of Educational Technology*, 14: 89-100.

Paper received for publication on July 2015
Paper accepted for publication on November 2016