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## Lessons learnt from teachers' perspectives on mobile learning in South Africa with cultural and linguistic constraints

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South Africa's classrooms are characterised by a wide variety of cultural and linguistic differences, providing teachers with educational challenges, particularly in mathematics and science subjects. In response, various mobile learning systems have been developed and piloted in the North West and Gauteng Provinces of South Africa. A framework has been proposed to support the development of similar technologies to be used in multilingual contexts. This paper evaluates teachers' perspectives on this framework using interviews with eight teachers from a mixture of urban and rural schools in various locations across the two provinces. The results of the study reflect the important roles that language and culture play in the technology needed to support learning in linguistically diverse schools. They highlight the challenges that teachers in schools face in diversely linguistic classrooms and how technology can be used to enhance such classrooms.

**Keywords:** mobile learning; schools; Setswana; South Africa; teachers

### Introduction

Technology has become an important aspect of the teaching and learning process across the world. In South Africa teaching and learning through technology has to consider the existing challenges of the South African classroom context. The lack of technology to facilitate the blended learning perspective and the use of multiple languages affecting the content used in the technologies are important factors affecting learning in the country (Jantjies & Joy, 2015).

Considering the lack of access to devices such as desktops for learning, due to the low cost and ease of access, mobile devices have been used across the world to offer a platform for teaching and learning (Botha & Butgereit, 2012; Pimmer, Brysiewicz, Linxen, Walters, Chippis & Gröhbiel, 2014). The assimilation of mobile phones as the most accessible mobile technology is also visible in many developing countries that have experienced increasing mobile phone penetration (International Telecommunication Union (ITU), 2015). In this paper, we present a study in which South African high school teachers provide perspectives on using multilingual mobile learning technology to support teaching and learning in science and mathematics classrooms. Through a convenience sampling technique, we identify and interviewed a total of eight teachers from urban and rural schools. The teachers were chosen based on the access granted by the Department of Education (DoE) to schools in the provinces, which were the same teachers who had participated in previous studies by Jantjies and Joy (2012, 2013, 2015). The teachers were then given an opportunity to provide their views on mobile learning in classrooms through an interview process through open-ended questions. Our study has considered the bilingual teaching environment of South Africa, one that has often lead to teachers switching between learners' native languages and English as their language of teaching and learning. The objective of our study has therefore been to address the following research question: *What are the teacher's perspectives in relation to bilingual mobile technology use in classrooms?* The results of the study were analysed through a thematic analysis approach with themes being derived from the research objective.

### Literature Review: Teachers and Technology

The use of technology in traditional classrooms also depends on the skills and perspectives of the teachers within those classrooms. In many countries teachers still struggle to integrate technology to support the teaching and learning process. These problems can be attributed to many factors, which include teachers' lack of expertise and the lack of appropriate technology and infrastructure (including technology support) to enable an integrated electronic learning environment (Bitner & Bitner, 2002; Roth, 2014), while in some contexts the teacher's everyday life is characterised by a lack of technology use. Although other factors hinder the adoption of technology in classrooms across the world (Brand, 1998; Bitner & Bitner, 2002; Judson, 2006), the issues outlined above stand as common problems faced by teachers when using technology.

Despite the challenges faced by teachers in using technology to support learning, devices such as mobile phones, tablets and similar mobile platforms have been used in South Africa in order to demonstrate the potential of integrating technology into learning.

### The Role of Language in Education

South African classrooms are characterised by multilingual teaching and learning approaches. The term *code switching* has been used to classify this phenomenon of moving between languages to communicate or explain a concept. Code switching is common to bilingual classrooms and involves the use of two languages to communicate in a conversation or exchange (Setati, 2008).

Then and Ting (2011) conducted a study on the reasons for code switching in classrooms, examining it from the teachers' perspective. This study was performed in Malaysian schools, where both the learners and teachers were bilingual. The teachers described the challenges they encountered when teaching bilingual learners. The study demonstrated that, in many instances, learners failed to understand and easily grasp classroom content requirements as a result of lacking proficiency in the academic language.

The study revealed that learners were likely to produce unrelated answers to tasks, motivating teachers to code-switch in order to ensure that learners understood the necessary concepts. Teachers also found it easier to use more than one language of communication to assist them in understanding the taught content. This problem was not only experienced in language classes, but also across other subject areas.

The use of more than one language in education has both advantages as well as disadvantages. The benefit of code-switching lies in the ability to reiterate a concept in the learner's mother tongue, and so to enable the learner to gain confidence and acquire knowledge through a holistic explanation and understanding of the topic. The adverse challenge can be the slow acquisition of the second language due to the constant switch between the learner's first and second language (Garegae, 2008).

### Using Multilingual Technology to Support Learning

MELFA was a project initiated to teach people suffering from dyslexia. The principle was to use voice technology in mobile phones to teach building construction employees in a learning programme available in both isiXhosa and English (with both languages being some of the official languages of South Africa). Originally developed and used in Denmark, MELFA was one of the earliest examples of how mobile learning can be contextualised to support a diverse linguistic community (UNESCO, 2012).

The Dr. Maths initiative has also made an important contribution to the use of multiple languages to support teaching and learning through mobile technology. Dr. Maths was launched by the Meraka Institute, which forms part of the South African Council for Scientific and Industrial Research (CSIR). The tool is founded on a chat-

room environment where high school learners and university students acting as mathematics tutors, both accessed the system. In this programme, the tutors would access the system remotely through desktops, while the high school learners would access the system through their mobile devices from any location. Learners would thus ask their tutors questions related to mathematics on their homework or any mathematical challenge. The learners were supported through these sessions in English, and at times through Afrikaans (Butgereit, 2007, 2012; Vosloo & Botha, 2009).

Yoza introduced mobile novels in isiXhosa and English. Users of the system were able to download the novels onto their mobile phones and access the novels in both languages. The users would then provide responses on their perspectives after reading these novels (UNESCO, 2012). Various mobile learning technologies have been developed to support learning in multiple languages. However, no technology has yet been developed that addresses learning in formal classroom settings by considering the code-switching nature of learners.

### Previous work: Studies on Multilingual Mobile Learning

In response to the cultural and linguistic challenges faced by South African schools, three studies by Jantjies and Joy (2012, 2013, 2014) have been conducted, where multilingual mobile learning systems were developed to support teaching and learning in South African classrooms.

In the first study, an online mobile learning software called M-Thuto was developed with the participation of teachers, who provided the learning content of the technology. M-Thuto is an abbreviation for the words mobile (M) learning (Thuto) directly translated from one of the South African languages being Setswana (Jantjies & Joy, 2015). This tool has enabled learners aged between 15 and 18 years of age to access different customised mobile resources, based on their mathematics curriculum. These resources included class notes, class exercises and quizzes presented in English and other South African languages, including Setswana. The software therefore enabled learners to switch views of the language at any point during their learning process. The switch would mostly occur whenever they felt that they could not understand the content (Jantjies & Joy, 2012).

In the second study, children aged between 15 and 18 used mobile devices to create voice clips expressing their understanding of the physical science classes. After every lesson learners were tasked with summarising their understanding of each lesson. The children could switch between any of the official languages, which they usually used to communicate with their teacher, including

English. They would frequently upload the mobile clips onto an online system, to which the teacher had access. The teachers would then listen to each learner’s clips, so enabling them to monitor each learner’s understanding (Jantjies & Joy, 2013).

In the third study, using the results of the two previous studies, we created a framework that can be used by software developer in the development of multilingual mobile learning technology to be used in similar contexts (Jantjies & Joy, 2014, 2015).

While there have been many studies reflecting on the use of technology to support the process of teaching and learning, there is a need for studies that consider the contextual language challenges faced by teachers within schools. While this study does not focus on the framework, we evaluated teachers’ perspectives on the Jantjies and Joy (2014) framework assessing the feasibility of its recommendations.

**Methodology**

A total of eight teachers from public (government) high schools in South Africa participated in this study. Each teacher was selected using a convenience sampling technique (Bryman, 2012) in which a request was sent to teachers who had participated in previous studies (Jantjies & Joy, 2012, 2013). The selection process was also based on the number of schools, in which the government granted us permission to conduct research, and thus our pool of teachers was limited to these schools.

Each teacher participated in a semi-structured interview session lasting up to an hour. The data

emanating from the study was analysed through a thematic analysis approach. The themes were developed from the framework objectives (Jantjies & Joy, 2015), and thus each theme reflects suggests aspects that need to be considered when developing multilingual mobile technology to be used in a South African context. Table 1 presents each theme and related questions from the interview guide. In figure 1, we also present the different schools and background of schools in which they taught, as this may have an influence on their perspective in the study. While the continuous evolution of schools in South Africa is aimed at improving education, much of the current structure of schools still represents the country’s apartheid legacy. Previously, schools were resourced and funded according to where the school was situated. Urban schools were often reserved for the white community, and were thus well-funded and resourced. Most urban schools still follow similar structures compared to their rural school counterparts, even though the demographics of learners and teachers has significantly changed in urban schools, with schools having a variation of races, regardless of their geographic location. The teachers participating in the study were all from different types of schools and faced unique challenges in each of their schools (as illustrated in Figure 1).

As the South African government works towards changing the imbalances in school, these problems continue to affect the structure and performance of schools.

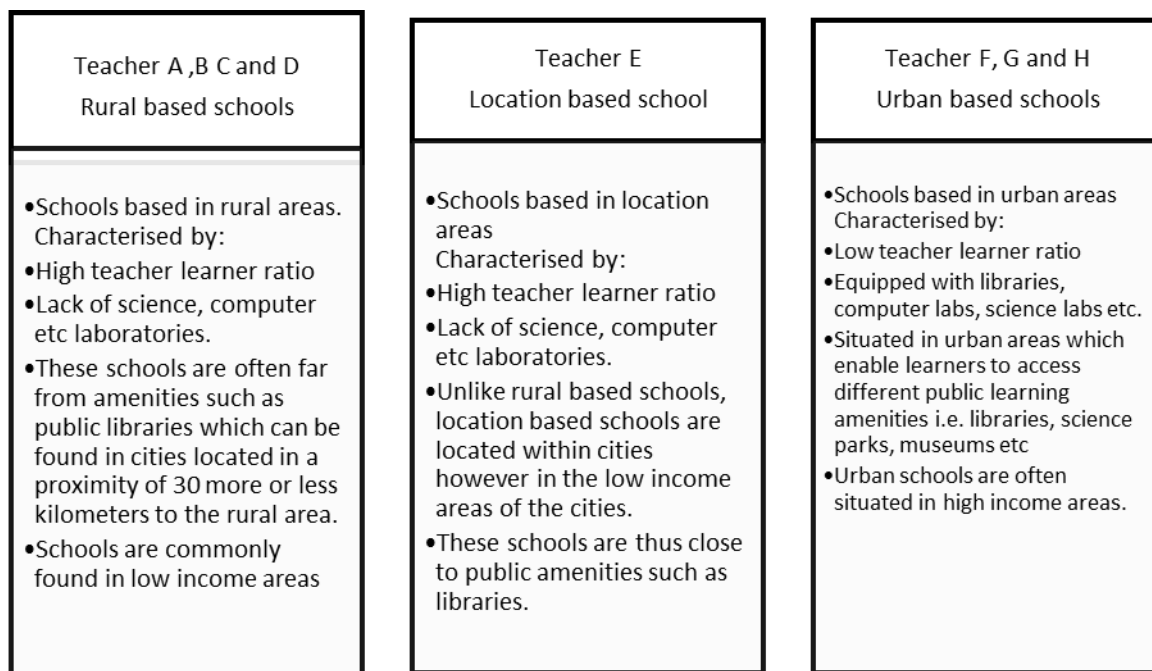
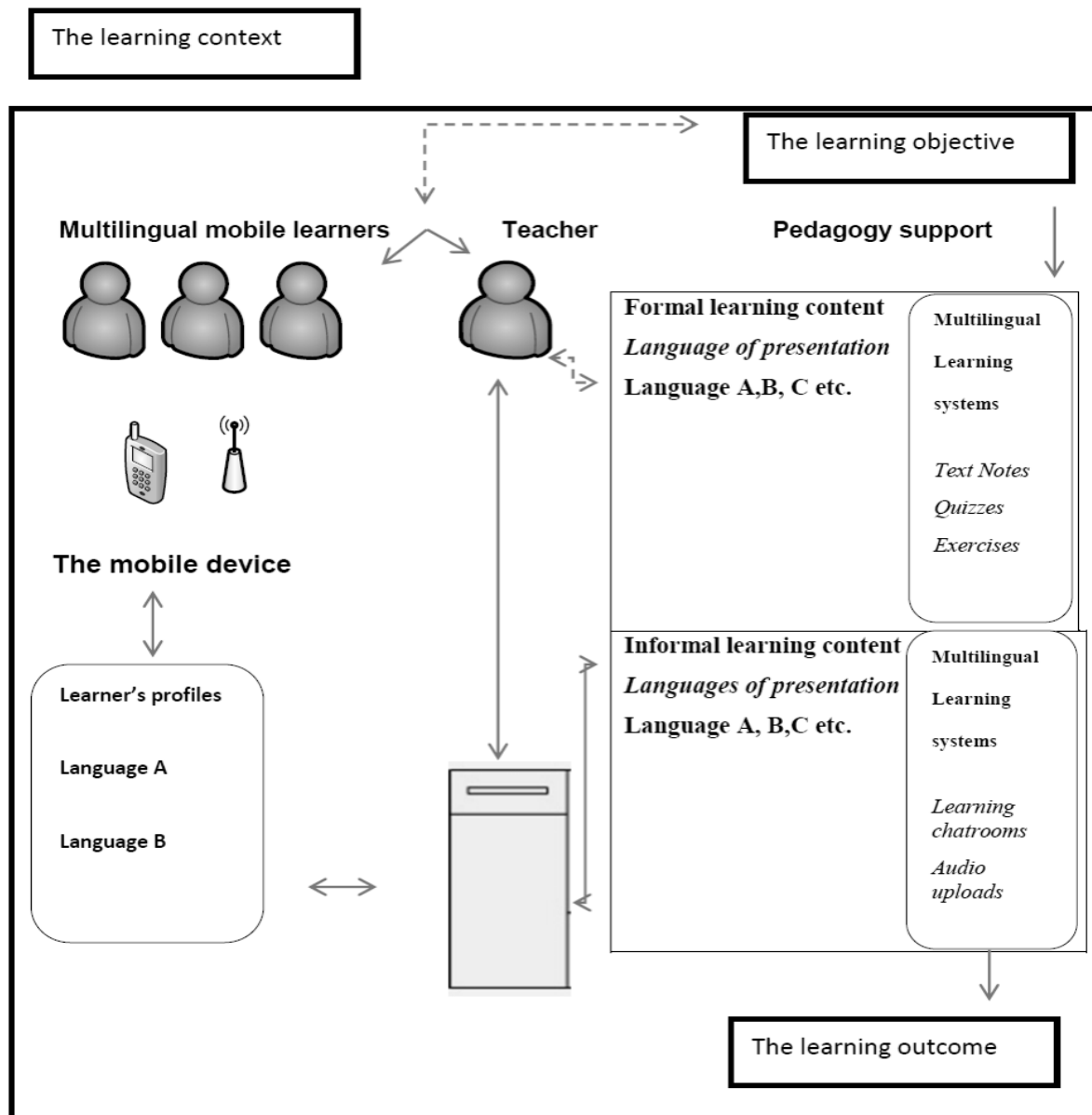


Figure 1 School environments (Jantjies, 2014)

### The Technology and Framework

One of the challenges that software developers often face is the challenge of developing learning technologies to support learning in contexts with which they may not be familiar. Here, M-Thuto has enabled teachers to provide learners with mobile-based learning activities for mathematics and science. Such learning activities have been developed in conjunction with the teachers, based on the support needed for children to reach the objectives of the South Africa curriculum for the relevant learning grade. As we have explained in detail above, the learning content provided for the M-Thuto programme has also considered the

multilingual learning background of learners in schools. Figure 2 illustrates the framework of the ecosystem from which the questions were drawn (outlined below) giving the study results. The diagram in Figure 2 represents the development of the mobile learning content to be developed, in order to support teaching and learning on mobile platforms. Figure 2 thus allows us to consider the contextual environment in which learning occurs, where the system users are the multilingual mobile learners and the learning platform is given in the mobile devices used, and where the language of teaching and learning and the pedagogy are illustrated accordingly.



**Figure 2** A multilingual mobile learning eco-system (Jantjies, 2014)

Figure 2 represents an ecosystem, where the teachers and learners are users of the technology. The system considers the different types of mobile

technologies, which learners will use to access learning systems particularly through the use of low-end mobile devices, since many children in

developing countries now have more access to such devices.

The role of the teacher is therefore to define and facilitate the role of the learning technology to support learning across the formal and informal learning spaces. The role of the technology, in this case, is to assist learners to achieve the learning objectives as set out by the national curriculum objective. The learning profiles contained in the system then give learners an opportunity to access the records. These will assist both the learner and the teacher in monitoring the learners' process of gaining knowledge at their own pace. The use of learning profiles in this program enables learners to choose their language and to switch the language view during the learning process. In terms of pedagogical support, the system designers have considered formal and informal learning spaces enabling the pursuit of activities best suited for the

different contexts in which learners find themselves. The framework was developed to guide the development of multilingual software to be used to support the process of teaching and learning in developing countries. In this study, we reflect on the framework, which was used to guide the development of the questions presented to the teachers. The following questions were then posed to teachers regarding the role of mobile learning in supporting multilingual teaching and learning, with the overall aim of analysing the eco-system outlined above and so the different technologies analysed in the research of Jantjies and Joy (2013, 2014, 2015).

### Results

The following themes and related sample questions were used to gather data from the participants.

**Table 1** Thematic analysis (Jantjies, 2014)

Theme	Interview questions
Multilingual support in the learning process	<p>What are the language policies for teaching in your school? How many languages do you usually use for classroom teaching?</p> <p>If there is any code-switching (switching between two or more languages while talking) that occurs, when does the switch occur from English to the other languages (for example, when a learner does not understand what you said, when you are introducing a new topic, or when the learner asks a question showing a lack of understanding in the language that you have used)?</p> <p>In which subject areas do you regularly switch between languages?</p>
Code-switching in formal and informal learning	<p>Given the switching reasons mentioned above, how would you use the switch in a formal content presentation for learners, when you create learning content for formal classroom teaching: (a) after every word; (b) after each sentence; (c) after every paragraph?</p> <p>How and why would you also use switching to present informal learning content by: (a) reformulating or rephrasing concepts from language A to B to learners; (b) introducing new concepts to learners in language A and after a significant amount of content explaining the same concept in another language; and (c) directly translating each content and concept from language A?</p>
Culture of supporting teaching and learning through mobile technology	<p>What are the types of activities that you would use to facilitate the learning process in your class?</p> <p>Do you ever encourage your learners to use computer, internet or technology resources to search for information?</p> <p>Which of these methods do learners in your class use to obtain learning material: text books, their class notes, websites, newspapers or videos?</p> <p>Does your school have a computer or computers?</p> <p>What does the school use computers for?</p>

### Limitations

In conducting studies in high schools, for each study done, we had to submit an ethics application to the South African government. The study pop-

ulation was limited to the number of schools the government had given us access in which to conduct the studies reflected here (Jantjies & Joy, 2012, 2013, 2014, 2015). We also had a limited

number of participating teachers in the study, limiting our study's ability to generalise the research findings.

#### Multilingual Support in the Learning Process

In this section, we asked teachers about the role that language plays in their schools in relation to policy, during the teaching and learning process and when using mobile devices. We wanted to identify how language was used and if any code-switching was used in the teaching and learning process. We observed that there was a consistent use of English as the main language of instruction in all schools. However, teachers F, G and H responded that the schools in which they taught restricted how they used language to support the teaching process in class. All the other teachers expressed the support that the school had in teaching using both the learners' home languages and English to support the teaching and learning process.

Teacher F (a mathematics teacher) expressed that it was difficult for him to conduct lessons without also having to use the learners' home language (Setswana), particularly if the learners "displayed a difficulty in understanding the class." Teachers E, G and H did not code-switch at any point during their teaching process. Teacher G was an Afrikaans-speaking teacher, and was not conversant with the local language, while teacher E was a foreign expatriate teacher who did not speak the local languages. Finally, while Teacher H was a fluent Setswana speaker, he believed that learners would only be able to speak and learn through English if they did not switch between languages. "The challenge with moving between languages is that our learners will take long to learn the language of teaching and learning; it is thus my role to help them to learn the subject and the language." The results reflected the diverse background of the different participants in using language to support multilingual classrooms. Nonetheless, it is important to note that teachers were mostly unclear about their schools' language policy for teaching and learning. This lack of transparency was especially visible in schools that were formerly known as 'Model C' schools; that is, urban schools reserved for 'white' learners. In contrast, South African education policy states that native languages can be used to scaffold the process of teaching and learning in schools (DOE, 1997). In spite the differences in language use perspectives, all the teachers reflected constructively on the role that language plays in how their learners interpret content, this in coherence with many findings reflecting on the effect of language on the learning process especially in mathematics classrooms (Durand-Guerrier, Kazima, Libbrecht, Ngansop, Salekhova, Tuktamyshev & Winsløw, 2016; Moschkovich, 2007; Setati, 2008).

#### Code-switching in Formal and Informal Learning

In this section, we wish to establish how teachers use code-switching to support learning in classrooms. The framework given in prior research Jantjies (2014) and Jantjies and Joy (2014) provides three different ways in which code-switching can be embedded into technology to support multilingual mobile learning. These are:

1. To introduce learning;
2. To reinforce learning (Setati, 2008);
3. To enable word-to-word translation.

We subsequently asked teachers whether they used any of the proposed methods to support code-switching in their own teaching process. Participating teachers A, B, C, D and F explained that they frequently used methods 1 and 2 to support teaching, while the other teachers stated that they used none of the methods, as code-switching was prohibited in their schools. Since the participating teachers were mathematics and science teachers, the third technique was not used at all.

All of the teachers reflected upon the constant challenge of reinforcing learning content for non-native speakers of English. Furthermore, code-switching only occurred verbally in classrooms where teachers used it to support learning. Teacher F, who was a mathematics teacher, reflected that, "subjects such as mathematics affect our ANA performance, which is the national assessments annual report that reflect on the quality of education in high schools. Looking at the report, you see that often students don't do well because of language rather than the subject." In contrast, none of the teachers used code-switching techniques to support written content. It was thus interesting to note their reaction when seeing the different ways in which, using the above techniques, technology could be used to support written content.

Figure 3 shows the presentation of content through two different views of the same content in two different languages. The student could move from one view option to another at any point in their learning experience. We showed a similar view to the teachers as a means of supporting the introduction of content and of reinforcing content to learners who currently code-switch.

Figure 4 illustrates the concept of *direct translation*. In instances where interpreters are a scarce resource to support the process of content translation, Jantjies and Joy (2014) note that automated translation tools can be embedded in the technology. They suggest the following technique (Figure 4) similar to Van Huyssteen, Puttkammer and Schlemmer (2007) to enable readers to view a single word in the text, thereby giving them the opportunity to view its translated version while learning. In Van Huyssteen et al. (2007) a similar technique is used to present a multilingual website for university students to gain information on the university offered subjects, which is able to high-

light a specific word in the text and find its alternative in another language.

The participating teachers cited content created in two different languages as an important way of introducing content to multilingual learners, although some teachers cited the inability of direct translation to capture the essence of the content.

The consistent perspective was that this view does not provide “quality learning material” (Jantjies, 2014:226) because, learners would be unable to correlate the sense of the content alongside its translated version. That is, in preference to reading the entirety of the content in one language, and then moving on to reading it in another language.

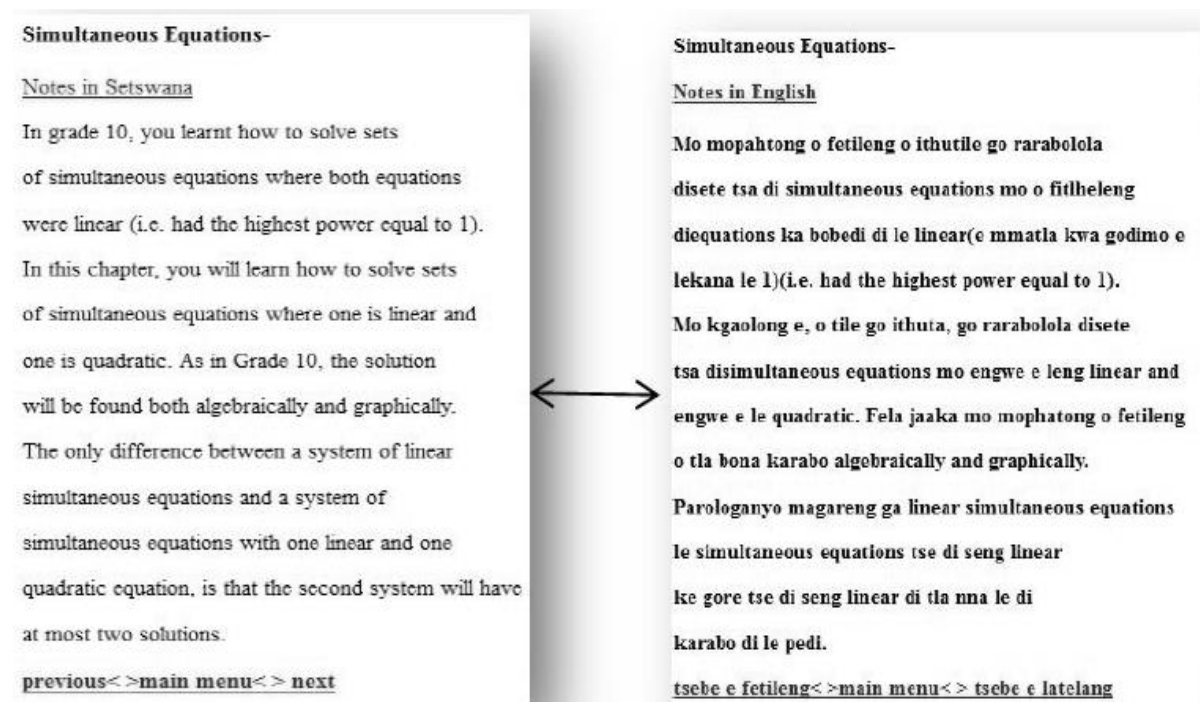


Figure 3 The same content created in different languages (Jantjies & Joy, 2014)

An example of supporting translation techniques on a mobile learning system

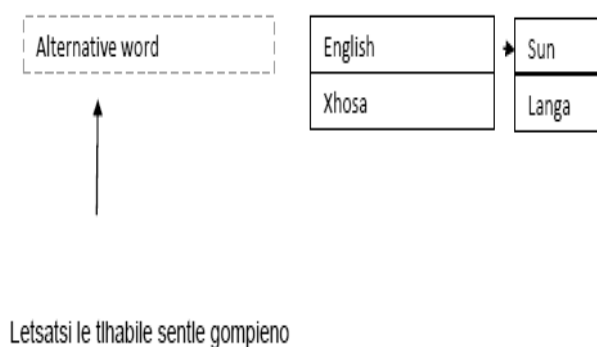


Figure 4 Direct translation of learning content (Jantjies & Joy, 2014)

Culture of Supporting Teaching and Learning through Mobile Technology  
 In recognition of the fact that technology is becoming a part of everyday learning across the

world, teachers are now being pressured to use some form of technology in their teaching. For our research, we asked teachers for their perspectives on the current uses of technology to support learn-

ing in relation to the challenges that come with creating a technology enhanced learning environment.

In seeking to understand how technology is used in these schools, we first questioned teachers about their formal training in supporting learning through technology. All the teachers agreed that they had not received any educational training on using learning technology. Teacher A noted, "there is often so much pressure to use different curriculums [sic] that things such as technology are not easy to consider when preparing for class." Only three teachers considered that, in their daily lives, they had some elementary knowledge of using technology such as computers. Although all the schools possessed computers, only schools in the urban areas provided Information and Communications Technology (ICT) lessons. It should also be noted that none of the teachers participating in a study were ICT teachers.

The teachers highlighted that they were not using any form of technology to present content to learners, and to support the learning process. We also asked teachers if they ever referred learners to any form of technology to enhance their learning. One teacher reflected that they often referred their students to the government-developed Mindset programme, which enables students to access on-line videos related to mathematics. Mindset enables different videos to be accessible for broadcast online, featuring various mathematics experts tackling a variety of mathematics topics related to the school curriculum. However, none of the teachers were, beyond this, aware of software applications or any learning technology specifically designed to support multilingual teaching and learning in high schools.

Despite the teachers' lack of technology skills, they still managed to give learners tasks which required the use of technology, such as looking up information on the internet. Comparatively speaking, teachers in the final school grades (11-12) distributed the least amount of work to be done on a computer, while teachers in the lower grades of learning gave out the most activities, requiring some form of technology. The reason was that teachers in the final grades often felt that they were under more pressure to give students work, and did not have the time to use technology to support learning, often viewing this approach merely as extra work. One of the teachers noted, "there are so many expectations from matric teachers in schools that we are often feeling [sic] discouraged to venture into anything new". Teacher A further reflected that, "it is very difficult to stick to a lesson plan and a curriculum while using technology to teach."

The lack of teacher training to embed technology into the daily teaching and learning process often creates an extra load for teachers, as they

need more time to learn how to use technology to their benefit (Charbonneau-Gowdy, Capredoni, Gonzalez, Jayo & Raby, 2016).

Our participating teachers were then asked how they conducted their daily lessons, with the aim of establishing how they might use the simplest type of technology to support learning. All of the teachers generally used traditional teaching methods, introducing new topics to learners through notes on the chalkboard. They felt this approach worked because learners were able to take down notes and examples of new ideas, thus giving them something to refer back to when revising the topic.

In this vein, teachers would then refer students both to the prescribed textbook, and to appropriate websites for further information on the topic. The most common practice in mathematics classes was to refer learners to the exercises available in their prescribed textbook. Most teachers cited the textbook and the local newspaper as the main sources of learning content, but in the urban school, Teacher F also cited YouTube videos and Mindset videos.

It was also interesting to note that teachers cited sources that were often based on the resources to which their learners had greatest access. Teachers would then assess students principally by using class quizzes, tests or an examination.

## Discussion

Many of the teachers participating in our research had access to different forms of technology, including laptops. It was important to note that most of the participants did not use this technology actively as a teaching and learning support. The cultural practice of teaching in high schools did not historically support technology use in schools, while teachers reflected upon the importance of teacher training, which would enhance their teaching practices in embedding the use of different technologies.

Despite their own inability to use technology to support teaching and learning, teachers often gave learners tasks requiring the use of technology. Furthermore, teachers reflected that they often cited sources to which their learners had greater access, such as online videos and textbooks. Although they are aware that mobile phones provide access to the internet, we found that generally, teachers had not yet realised their potential as a teaching and learning tool.

Moreover, many teachers do not have knowledge of technologies that can support learning. There is thus a need for adequate training and support to facilitate teaching through technology in both urban and rural schools. Bitner and Bitner (2002) highlight the importance of teachers as key role players in embedding technology within schools. The authors further present that many



technology initiatives conducted in schools discard the importance of the teacher in the success of technology. Winters (2013) cites the lack of teacher support and upskill as one of the key factors leading to the failure of IT initiatives such as mobile learning in schools.

Language plays a crucial role in mathematics and science education across the different schools where our study participants teach and study. In spite of schools having different language policies, teachers thus continue to be challenged by learners' interpretation of learning materials. Setati (2008) reflects on the role that language plays in mathematics classes in South Africa, as it affects the time it takes for learners to grasp concepts, creating a challenge that teachers have to overcome in their teaching process. The teachers in our study have provided various views about mobile learning technologies, which support multilingual mathematics learning. The teachers in our study generally emphasised a need for technology supporting different multilingual techniques, particularly for Science, Technology, Engineering and Mathematics (STEM) subjects.

### Conclusion

This paper has presented a survey on the perspectives of teachers on the use of mobile learning technology to support multilingual learning. The teachers from the different schools in South Africa participating in the study have provided details of their background use of technology in supporting the teaching and learning process. Their input has helped us to highlight the cultural practices of using technology to support teaching and their perspectives on the use of mobile technology to support multilingual learning in STEM-related subjects.

Our study has found that some teachers were active in using various methods to support multilingual learning in mathematics and science classrooms, however, that they have been unable to integrate technology to support the process of teaching and learning. Furthermore, the teachers reflected on different challenges, such as lack of teacher training in ICT use, which have prevented them from realising the possibilities of achieving teaching objectives with the assistance of technology.

The teachers were generally enthusiastic about the potential of technology to support teaching within the classrooms.

In this study, we found that the role of mobile technology can be fully realised, when relevant consideration is given to the context of the learning environment. In order to ensure the sustainable use of technology in schools in developing countries and across the world, context, culture and language thus become key factors in the development and use of technology in education. This study reflected

on the importance that teachers, context, technology and language play in the content creation process of learning technologies and the use of technology to support the process of teaching and learning.

There is a need for research that reflects on the role that language and contextual challenges play in the development of mobile learning systems, and for content to be used to support the pedagogy. In future studies, we aim to establish a pedagogical paradigm, which can be developed to consider language and context when using technology to support pedagogy.

### References

- Bitner N & Bitner J 2002. Integrating technology into the classroom: Eight keys to success. *Journal of Technology and Teacher Education*, 10(1):95-100.
- Botha A & Butgereit L 2012. Dr. Math: A mobile scaffolding environment. *International Journal of Mobile and Blended Learning (IJMBL)*, 4(2):15-29. doi: 10.4018/jmbl.2012040102
- Brand GA 1997. What research says: Training teachers for using technology. *Journal of Staff Development*, 19(1):10-13.
- Bryman A 2012. *Social research methods* (4th ed). Oxford, NY: Oxford University Press.
- Butgereit L 2007. *Math on MXit: the medium is the message*. Paper presented at the 13th Annual National Congress of the Association for Mathematics Education of South Africa (AMESA), White River, 2-6 July. Available at <http://researchspace.csir.co.za/dspace/handle/10204/1785>. Accessed 18 August 2016.
- Butgereit L 2012. *Dr Math at your service*. Paper presented at the 4th CSIR Biennial Conference: Real problems relevant solutions, Pretoria, 9 October. Available at [http://researchspace.csir.co.za/dspace/bitstream/10204/6175/1/Butgereit4\\_2012.pdf](http://researchspace.csir.co.za/dspace/bitstream/10204/6175/1/Butgereit4_2012.pdf). Accessed 18 August 2016.
- Charbonneau-Gowdy P, Capredoni R, Gonzalez S, Jayo MJ & Raby P 2016. Brave forms of mentoring supported by technology in teacher education. *The Electronic Journal of e-Learning*, 14(1):3-14.
- Department of Education (DOE) 1997. *Language in education policy*. Available at: <http://www.education.gov.za/LinkClick.aspx?fileticket=XpJ7gz4rPT0%3D&tabid=390&mid=1125>. Accessed 31 January 2015.
- Durand-Guerrier V, Kazima M, Libbrecht P, Ngansop JN, Salekhova L, Tuktamyshov N & Winsløw C 2016. Challenges and opportunities for second language learners in undergraduate Mathematics. In R Barwell, P Clarkson, A Halai, M Kazima, J Moschkovich, N Planas, M Setati-Phakeng, P Valero & MV Ubillús (eds). *Mathematics education and language diversity*. Switzerland: Springer International Publishing. doi: 10.1007/978-3-319-14511-2\_5
- Garegae KG 2008. *Language in mathematics education: A double jeopardy for second language learners*. Paper presented at the 11th International Congress of Mathematics Education (ICME), Monterrey, 6-13 July.

- International Telecommunication Union (ITU) 2015. *ICT facts and figures – The world in 2015*. Geneva, Switzerland: ITU. Available at <https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf>. Accessed 11 November 2015.
- Jantjies M & Joy M 2013. Mobile learning through indigenous languages: learning through a constructivist approach. In *12th World Conference on Mobile and Contextual Learning (mLearn 2013)*. Doha, Qatar: QScience Proceedings. doi: 10.5339/qproc.2013.mlearn.14
- Jantjies M & Joy M 2015. Mobile enhanced learning in a South African context. *Journal of Educational Technology & Society*, 18(1):308-320.
- Jantjies ME 2014. A framework to support multilingual mobile learning: A South African perspective. PhD thesis. England, UK: University of Warwick. Available at [http://wrap.warwick.ac.uk/62611/1/WRAP\\_THESIS\\_Jantjies\\_2014.pdf](http://wrap.warwick.ac.uk/62611/1/WRAP_THESIS_Jantjies_2014.pdf). Accessed 18 August 2016.
- Jantjies ME & Joy M 2012. Multilingual mobile learning: a case study of four South African high schools. In *11th World Conference on Mobile and Contextual Learning (mLearn 2012)*. Helsinki, Finland: CEUR-WS. Available at [http://wrap.warwick.ac.uk/59540/1/WRAP\\_Jantjies\\_paper\\_68.pdf](http://wrap.warwick.ac.uk/59540/1/WRAP_Jantjies_paper_68.pdf). Accessed 18 August 2016.
- Jantjies ME & Joy M 2014. *A framework to support mobile learning in multilingual environments*. Paper presented at the 10th International Conference on Mobile Learning, Spain, 28 February – 2 March. Available at <http://files.eric.ed.gov/fulltext/ED557239.pdf>. Accessed 18 August 2016.
- Judson E 2006. How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education*, 14(3):581-597.
- Moschkovich J 2007. Using two languages when learning mathematics. *Educational Studies in Mathematics*, 64(2):121-144. doi: 10.1007/s10649-005-9005-1
- Pimmer C, Brysiewicz P, Linxen S, Walters F, Chipps J & Gröbbl U 2014. Informal mobile learning in nurse education and practice in remote areas - A case study from rural South Africa. *Nurse Education Today*, 34(11):1398-1404. doi: 10.1016/j.nedt.2014.03.013
- Roth K 2014. Technology for tomorrow's teachers. *Journal of Physical Education, Recreation & Dance*, 85(4):3-5. doi: 10.1080/07303084.2014.884420
- Setati M 2008. Access to mathematics versus access to the language of power: the struggle in multilingual mathematics classrooms. *South African Journal of Education*, 28(1):103-116. Available at <http://www.sajournalofeducation.co.za/index.php/saje/article/view/150/99>. Accessed 18 August 2016.
- Then DCO & Ting SH 2011. Code-switching in English and science classrooms: more than translation. *International Journal of Multilingualism*, 8(4):299-323. doi: 10.1080/14790718.2011.577777
- United Nations Educational, Scientific and Cultural Organization (UNESCO) 2012. *Turning on mobile learning in Africa and the Middle East: Illustrative initiatives and policy implications*. Working paper series. Paris, France: UNESCO. Available at [http://tostan.org/sites/default/files/resources/unesco\\_turning\\_on\\_mobile\\_learning\\_in\\_africa\\_and\\_the\\_middle\\_east.pdf](http://tostan.org/sites/default/files/resources/unesco_turning_on_mobile_learning_in_africa_and_the_middle_east.pdf). Accessed 18 August 2016.
- Van Huyssteen G, Puttkammer M & Schlemmer M 2007. *Developing web-based word-translators*. Paper presented at the LVSA/SAALA/SAVTO Congress, Potchefstroom.
- Vosloo S & Botha A 2009. *Mobile learning: South Africa examples*. Paper presented at the Mobile Learning Institute Summit, Lusaka, 24-27 June. Available at <http://www.slideshare.net/stevevosloo/mobile-learning-south-african-examples>. Accessed 18 August 2016.
- Winters N 2013. *How teachers in Africa are failed by mobile learning*. Available at <http://www.scidev.net/global/education/opinion/how-teachers-in-africa-are-failed-by-mobile-learning.html>. Accessed 21 July 2016.