An investigation of how Visual Technology for the Autonomous Learning of Mathematics (VITALmaths) video clips on mobile phones can be used by student teachers as a visualisation tool in the teaching of Number Sense: A case study

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ABSTRACT

Visualisation is increasingly being recognised as having a significant role in the learning of mathematics especially when students are solving mathematical problems (Thornton, 2001). It is argued that visualisation is a powerful tool for learners to construct mental and physical representations that correctly mirror mathematical relationships and concepts. To gain a thorough understanding of the scope of visualisation, three Visual Technology for Autonomous Learning of Mathematics (VITALmaths) (www.vitalmaths.com) video clips were uploaded on mobile phones of each of the eleven participating student teachers who used them in their teaching practice. This is in cognisance of the educational potential offered by mobile phones and their current pervasiveness in the daily lives of both teachers and learners in Zambia (Zambia. Ministry of Education [M.O.E], 2013]). This study sought to investigate how VITALmaths video clips on mobile phones could be used by student teachers as a visualisation tool in the teaching of Number Sense. The videos of the lessons formed the core of my analysis. The study was conducted at four primary schools by eleven student teachers of a public university in Zambia. The study is framed as a case study and is grounded within the interpretive paradigm.

The findings revealed that the student teachers' use of the video clips in the classrooms for teaching was generally approached from two perspectives: at the beginning of the lesson or at the end. The videos were used at the beginning of the lesson as a means to introduce a topic or an idea, and at the end of the lesson to consolidate what was taught. The videos were also used to enhance the conceptual understanding of Number Sense. The findings also revealed that students encountered both enabling and constraining factors in their use of mobile phones to teach number sense. The overall findings revealed that, if well utilised, mobile phones as visualisation tools had the potential to enhance the teaching of Mathematics in general and Number Sense in particular, and therefore teachers should be encouraged to use them in their teaching.

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My wife Francisca, and children, Lukonde and Malama, for bearing my absence from home when I was away for my studies.

DEDICATION

This study is dedicated to our late son, Shoka, who passed on, aged 19, in his second year of study, at the University of Zambia, at a time I was doing the course.

Son, when I was told while I was attending the Research Design Course in Grahamstown that you were very sick and I indicated that I would cut short the programme and return, all you said, despite, being in pain was

"No dad, stay on and complete the programme, you will find me"

DECLARATION OF ORIGINALITY

I, Lemmy Kangwa, student number g13K6284, hereby declare that this thesis entitled "An investigation of how VITALmaths video clips on mobile phones can be used by student teachers as a visualisation tool in the teaching of Number Sense" is my own work, and a product of my research. It has not been submitted in any form to another institution. Where I have drawn on ideas of people from other publications or other sources, I have fully acknowledged these in accordance with Rhodes University, Education Department reference guide.

1st December 2016

Signature

Date

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

The past few decades have witnessed an increasing recognition of the role of technology in development efforts across the globe. The digital and information revolution has changed the way learning takes place and the way business is conducted worldwide. It has however been argued that most African countries, Zambia included, do not provide quality education to its learners because they do not take advantage of the potential Information and Communication Technology (ICT) offers to facilitate teaching and learning (Zambia. Ministry of Education [MOE], 2007).

The aim of this study was to investigate how Visual Technology for the Autonomous Learning of Mathematics (VITALmaths) (www.vitalmath.com) video clips on mobile phones could be used as a visualisation tool by student teachers in the teaching of Number Sense. The study was conducted in selected primary schools in Zambia and took the form of a case study. This chapter presents an introduction to the study by first considering the context, the research goals and methodology. It then focuses on the significance and limitations of the study, and finally gives the structure of the thesis.

1.2 BACKGROUND TO THE STUDY

One of the reasons cited for poor performance by learners across the Zambian mathematics education system is the lack of teaching that promotes conceptual understanding (Zambia. MOE, 2014). Kalimaposo (2010) is of the view that student teachers in Colleges of Education are unfortunately not sufficiently exposed to teaching methods that foster conceptual understanding and the construction of knowledge. One way in which conceptual understanding can be enhanced is by integrating appropriate technology in the teaching and learning process. The use of a mobile phone, a device that is pervasive among student teachers in Zambia and has the potential to be used as a visualisation tool could be one of the solutions.

Mobile technologies today are ubiquitous as a medium for communication globally, and as such the potential of mobile technology to change teaching and learning is immense (Garrison & Anderson, 2003 as cited in Ndafenongo, 2011). He postulates that the 21st century, has witnessed a number of changes regarding technological devices within and

outside the education spectrum. In the education sector, devices such as mobile phones and computers have been embraced especially among young learners. The opportunities that have come with modern technology call for realignment in the teaching and learning process in order to explore their educational potential. Prensky (2006) is of the view that the mobile phone is a tool that has great potential to be used in schools. Koebler (2011) agrees with Prensky and argues that communities faced with challenges of latest technology are likely to benefit from the educational affordances of the mobile phone. He added that the mobile phone is pervasive, costs relatively less compared to other gadgets, is easy to use, and that it is easy to set up mobile network even in areas where the infrastructure is poor.
According to Shuler (2014) the opportunities that mobile technologies can offer to mobile learning include: encouraging learning "anywhere, anytime; reaching deserving learners; improving twenty-first century social interactions; fitting with various learning environments and enabling personalised learning experiences (p. 29).

In my view, the potential of using mobile technologies in education is enormous in a country such as Zambia where there is limited access to electricity and landline telephone networks, poor roads, limited or no access to reliable computers and few people with the necessary skills to using computers. In the midst of all these challenges, mobile phone coverage in Zambia is very widespread compared to access to computers. The penetration rate of internet access is at 24 percent, landlines at 0.7 percent while that of mobile phones is 78 percent (World Stats, 2016). In addition, mobile technology is an interactive medium compared to other technologies.

A mobile phone has the potential to be used as a visualisation tool. One way in which this can be done is by uploading Visual Technology of Autonomous Learning of Mathematics (VITALmaths) (www.vitalmaths.com) video clips to mobile phones, and use the videos in the teaching and learning process in the classroom.

This database of the VITALmaths video clips were developed by a joint project of Rhodes University of South Africa and the North-Western University of Switzerland (Linneweber-Lammerskitten, Schafer & Samson (2010). The video clips visually present a variety of mathematics concepts on a variety of topics that include Sum of Consecutive Odd Numbers, Rectangular Products and Palindromic Sums. Natural materials are mostly used to develop these short video clips of 1 to 3 minutes long. The VITALmaths project uses Mobile phone technology as the primary distribution platform for the video clips. (Linneweber-

Lammerskitten et al 2010). The features of the video clips include being visually appealing, and having the potential to be used as a visualisation tools when uploaded to mobile phones. The text in the video clips is in three languages: English, isiXhosa and Germany, and they are generally self-explanatory requiring minimum mathematical proficiency to interpret and conceptually understand the concepts (ibid).

According to Linneweber- Lammerskitten et al., (2010) "the video clips encourage genuine mathematical exploration that transcends the mere mathematical content of the film by encouraging a desire to experiment, use trial and-error, formulate conjectures, and generalize results" (p. 355). This aligns well with the Zambian National Numeracy Framework (NNF) whose aim is "to provide strategies to improve and enhance performance in learners through the use of more effective modes of instruction and presentation of numeracy in teaching and learning" (Zambia. MOE, 2014, p. 1). In my view VITALmaths video clips could be part of such modes of instruction in the Zambian mathematics education system.

Thornton (2001) observes that there is a growing recognition that visualisation plays a significant role in the learning of mathematics. From a mathematical perspective, different authors have defined visualisation in a number of ways. Arcavi (2003) contends that

> "Visualisation is the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds on paper or with technological tools, with the purpose of depicting and communicating information, thinking about and developing previously unknown ideas and advancing understanding", (p.217).

Generally it is agreed that visualisation plays a number of important roles in students' capacity to solve problems. For example, Ho (2010) and Zimmerman and Cunningham (1991) note that visualisation does not equate to just forming a mental image, but rather it is specifically about visualising a concept or problem rather than an idea. They described visualisation as "the process of producing or using geometrical or graphical representations of mathematical concepts, principles or problems, whether hand drawn or computer generated (Zimmerman and Cunningham, 1991, p.1).

1.3 SIGNIFICANCE OF THE STUDY

The Zambian National Information and Communication Technology (ICT) policy recognises the importance of technology in the education system. One of the objectives of the ICT policy is "to provide … teaching materials for integration in the classroom for basic education, high schools, pre-service and in-service training to provide an alternative mode and facilitate access to the education materials" (Zambia. MOE, 2007, p. 19). The policy underscores the importance of ICT in schools and in teacher education institutions by acknowledging that "Educational imperatives stress the need to raise educational standards by the introduction of ICT into schools and teacher training" (Zambia. MOE, 2007, p. 3).

Despite such policy pronouncements, not much has been done to implement ICT into education especially in primary and secondary schools. The ICT policy does not allow learners to use a mobile phone in the premises of government primary and secondary schools. One reason cited is that it distracts learning.

In the Zambian curriculum, a lot of emphasis is on the computer as a primary medium of communication in ICT in primary and secondary schools. This is despite a number of challenges in the use of a computer in the Zambian learning institutions. These include: insufficient number of computers in schools, a number of schools not being connected to the electricity grid and erratic power supply, high cost of maintaining computers and lack of adequately qualified staff in ICT (Zambia. MOE, 2014).

These challenges were exposed in what was labelled as "the National ICT disaster of 2015" (Asamu, 2015). In the first ever compulsory practical Grade nine ICT examinations, a good number of candidates had to undertake their examinations well after midnight (see appendix E) forcing an outcry from parents and the general public. This was caused by inadequate computers and cuts in electricity supply forcing candidates to wait for their turn after their colleagues had completed the examination. The MOE insisted on conducting the practical examinations despite being aware that a good number of schools especially in the rural areas did not have a single computer with some schools having a ratio of 9 computers for every 600 pupils (ibid, 2015). The government has since rescinded the decision and made ICT an optional subject. The then minister of education, Dr. John Phiri, had to make a public apology.

In my view, such experiences justify the need for MOE to explore alternative ways of integrating technology in education, and the mobile phone is one gadget which is not only owned by many people but also abhors many challenges associated with a computer.

I therefore strongly feel that this study, to investigate the use of VITALmaths video clips on mobile phones by student teachers as a visualisation tool in the teaching of Number Sense, is not only necessary but timely in the Zambian context. The study will not only contribute to the existing literature, but will also provide a platform for stakeholders to discuss and hopefully find solutions to how a mobile phone, from a visualisation perspective, can be utilized in the Zambian classroom.

The major thrust of my study is to investigate how VITALmaths video clips uploaded on mobile phones can be used by student teachers as a visualization tool in the teaching of Number Sense.

1.4 RESEARCH GOAL AND QUESTIONS

1.4.1 Research Goal

The overall goal of my study is to investigate student teachers' use of VITALmaths video clips on mobile phones as visualisation tools in teaching number sense.

1.4.2 Research Questions

1. How can VITALmaths video clips on mobile phones be used by student teachers as a visualisation tool in the teaching of number sense?
2. What enabling and constraining factors do student teachers encounter when using mobile phones to teach Number Sense?

1.5 RESEARCH METHODOLOGY

In an interpretivist research perspective, researchers attempt to capture and share the understanding that participants in an educational encounter have of what they are teaching and learning (Kilpatrick, 1998). I intended in this study to investigate the personal interpretations and understanding of the experiences of eleven student teachers on their use of VITALmaths video clips on mobile phones in teaching Number Sense. The theoretical orientation that guided this study was therefore the interpretive paradigm and the theoretical framework was constructivism.

I employed a qualitative case study methodology of eleven student teachers of a public university in Zambia. The case in this study was the eleven student teachers teaching Number Sense using VITALmaths video clips that were uploaded on mobile phones. This

case study was a build-up on the studies undertaken by Ndafenongo (2011), Hyde (2011) and Haywood (2016) on using VITALmaths video clips in mathematics teaching. The unit of analysis was therefore the eleven student teachers' experiences of how they used the visualisation video clips on mobile phones to teach number sense. The research instruments I used were interviews, focus group discussions, discussions, observations, and document analysis.

The study took place at four primary schools where the student teachers conducted their teaching practice. The eleven student teachers were purposively selected and all taught Grade 7 classes.

The study was divided into six phases: Training and awareness; selection and planning; pilot and planning; implementation of the lessons; interviews and finally analysis. Data was analysed by considering emerging themes that were key in the teachers' experiences of the role that mobile phones played as visualisation tools when they were teaching.

1.6 LIMITATIONS

My study was a qualitative case study conducted on a small scale as it was only confined to four research sites and with only eleven participants. Despite a wide range of video clips available on the VITALmaths database, due to time constraints, I only used three video clips in the study, and a total of eleven lessons were presented by the participants. Due to these factors, the findings cannot not be generalised to a wider context. Additionally, I conducted my research project while I was still working on a full time basis, and the participants' academic programme was in session. This posed a challenge in that I could only meet the students and facilitate their movement to the schools when they were 'free', so the time dedicated to the study was inevitably limited. Not all the implementing schools were in the proximity of my work place, so there was a need to facilitate transport to the various schools, which was costly.

1.7 STRUCTURE OF THE THESIS

The thesis is structured in five chapters as follows:

1.7.1 Chapter One

This chapter gives a background to the study by considering the context: It states the research goals and the research questions. The significance of the study and its limitations are presented and finally the structure of the thesis is outlined

1.7.2 Chapter Two

This chapter analyses the literature relevant to the study. It first provides an overview of mobile technology and its significance in general, before focusing on its relevance to education. It then focuses on the importance and role of visualisation in education. It concludes with analysing how mobile phones can be used as visualisation tools to teach Number Sense.

1.7.3 Chapter Three

This chapter deals with the methodology of the study. It describes the theoretical orientation and framework, and then discusses the research methods. It explains the criteria used to select the participants and research sites. The research design and techniques are also discussed and it briefly describes how the analysis was done.

1.7.4 Chapter 4

This chapter deals with the presentation and analysis of data collected for the study. It gives a brief outline of how each video was used. The vertical analysis of the data focusses on how each of the eleven participants used the video clip in the lessons. It concludes with a horizontal analysis by focussing on enabling and constraining factors encountered by all participants as they used mobile phones in their lesson presentations.

1.7.5 Chapter 5

Being the final chapter, it presents a summary of the findings, the significance of the study and its limitations. It outlines some suggestions for further research and concludes with my personal reflections concerning the whole study.

1.1 CONCLUSION

This chapter gave a synopsis of this study by first presenting the background of the study and its significance. The two research questions that guide the study and the methodology were presented and finally it outlined how the thesis is structured.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The literature that provides the groundwork for this study is presented in this chapter. The purpose of this chapter is to provide a contextual background to the study. The main thrust of this study is to investigate how VITALmaths video clips on mobile phones can be used by student teachers as a visualisation tool in the teaching of Number Sense. In a broader perspective, the purpose of a literature review is to avoid rediscovering knowledge that has already been reported (Cohen, Manion & Morrison, 2011). It can also be used to identify gaps in the field of work the researcher is working on and to build upon it.

2.2 VISUALISATION

Visualisation is increasingly being recognised as having a significant role in the learning of mathematics especially when students are solving mathematical problems. It is argued that visualisation is a powerful tool with which learners can construct mental and physical representations that correctly mirror mathematical relationships and concepts (Kadunz & Straesser, 2004). In many areas of the curriculum, visualisation is an important facet. Its importance in mathematics has generated much debate (Arcavi, 2003; Bishop, 1989; Dreyfus & Eisenberg, 1986; English, 2013; Kadunz & Straesser, 2004; Presmeg, 1992; Stylianou & Silver, 2004).

As the global community moves rapidly towards the information age, the ability to reason visually is increasingly becoming important. Ultimately, this has contributed to more recognition of the role that visualisation plays in mathematical thinking and problem solving.

2.2.1 Definition of Visualisation

Generally, it is agreed that visualising is a critically important process when mathematicians and others actually do mathematics. Zimmerman and Cunningham (1991) note that our use of the term visualisation in mathematics is not the same as the everyday use of the term. It does not equate to just forming a mental image. Rather it is about visualising a concept or problem rather than an idea. Visualisation can be on paper, or using computer graphics, or in many other forms. Nemirovsky and Noble (1997) describe visualisation as the means of travelling between external representations and the learner's mind. Presmeg (1992) describes a continuum of visual imagery from concrete to abstract, and discusses the importance of students developing abstract patterns and dynamic imagery.

From a mathematical perspective, different authors have defined visualisation in a number of ways. Arcavi (2003) contends that:

> "Visualisation is the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about and developing previously unknown ideas and advancing understanding" (p.217).

Ho (2010) and Zimmerman and Cunningham (1991) note that visualisation does not equate to just forming a mental image, but rather it is specifically about visualising a concept or a problem rather than an idea. They described visualisation as "the process of producing or using geometrical or graphical representations of mathematical concepts, principles or problems, whether hand-drawn or computer-generated (Zimmerman & Cunningham, 1991, p.1). Durmus and Karakirik (2006, cited in Hyde 2011) state that mathematicians have long used tools and manipulatives, including computers, in the development of mathematical concepts and relationships using visual representations.

From another perspective, visualisation is regarded as the ability to see and understand a problem situation. Ho (2009) noted that in as much as the ability to solve problems is at the heart of mathematics, visualisation is at the heart of mathematical problem solving. Visualising an object or a situation encompasses "mentally manipulating various alternatives for solving a problem related to a situation or object without benefit of concrete manipulatives" (M.O.E., 2014, p.51). M.O.E. (2014) further acknowledges that visualisation is a vital skill that is indispensable in the learning and application of mathematics and is also an important cognitive tool in problem solving. Apart from the definition by Arcavi given above, other authors defined visualisation as presented below:

Visualising a situation or an object involves "mentally manipulating various alternatives for solving a problem related to a situation or object without benefit of concrete manipulatives" (Zambia. MOE, 2014, p. 51).

The way of acting with explicit attention to the possible concrete representations of the objects one is manipulating in order to have a more efficient approach to the abstract relationships one is handling, is what we call mathematical visualisation (Guzm'an, 2002).

The term visualisation is most often applied to public acts of communication: using a diagram or other representation as a vehicle to convey a mathematical idea, to explain or convince (Hanna & Sidoli, 2007). There are a number of types of visualisation as discussed in the section below.

2.2.2 Types of visualisation

There are a number of visualisation forms that can be used in mathematics lessons at both primary and high schools. Depending on the "degree of correspondence between the mathematical situation and the concrete way of representation, there can be a number of different types of visualisation (Guzm'an, 2011). Mesaros (2011) identifies four types of visualisation namely isomorphic, homomorphic, analogic and diagram visualisation. An attempt is made to distinguish between them (ibid, 2011).

Isomorphic representation depicts a situation where objects may have a "fixed" correspondence with the representations with which we associate them. This implies that in this type of visualisation, it would generally be possible to set rules to connect the features of our visual representation and the mathematical representations of the elements they represent. This could enable a transformation of visual manipulations of objects into abstract mathematical linkages ((ibid, 2011). .

Homomorphic visualisation is the kind of visualisation where some elements possess common relations that can replicate relationships between abstract objects and thereby provide support to guide our thinking in the mathematical procedure of "conjecturing, searching and proving" (ibid, 2011).

Mesaros (2011) accentuates that *analogical visualisation*, also referred to as analogical modelisation, is the type of visualisation where objects being worked on are substituted with others that have a relation between themselves in an analogous way. This presupposes that the behaviour of both types of objects had been earlier explored and is known to be easier to handle.

On the other hand, in *diagrammatic visualisation*, people's mental objects and their mutual relationships as regards aspects of their interest, are represented by diagrams that aid the thinking process (ibid,). Such diagrams have a similarity with mnemotechnic rules. Although in some cases such diagrams and symbolization can become generalised, in most cases they are very personal. They can however be communicated to others with little effort and can prove to be very useful. There is a view by some people that mnemonic images and diagrams create a series of obstacles to individual development in mathematics, since, they claim, what matters is only formal justification of arguments (ibid). On the contrary, another view holds that the success enjoyed by great teachers in mathematics more often than is not as a result of the effort they make to share and impart not only their and other people's results, but also the processes others used to obtain such results.

It should however be noted that the classification of the types of visualisation is neither clear-cut nor exhaustive as there are other types that cannot be classified under any of the types I have described above. Visualisation, as presented in the next chapter, has a significant role in Mathematics.

2.2.3 Role of Visualisation

There is a growing recognition that visualisation plays a significant role in the learning of mathematics (Thornton, 2001). The role of visualization in mathematics learning has been a subject of much research, (Arcavi, 2003; Bishop, 1989; Eisenberg & Dreyfus, 1986; English, 1997; Kadunz & Straesser, 2004; Presmeg, 1992; Stylianou & Silver, 2004).

Visualising in most cases in mathematics is associated with drawing pictures or diagrams as a first step to solving problems. Nonetheless, visualising has a bigger role to play in problem solving, which includes giving support to development of ideas and encouraging transmission of results and understanding, an indication that visualising is not only confined to pictures and diagrams.

It is generally agreed that visualisation plays a number of important roles in students' problem solving. These roles include those of understanding, simplifying, making connections, learning styles, substituting, checking and transforming (Ho, 2009). To underscore the importance of visualisation in mathematics, Ho (2009) posits that: If visualisation is at the heart of mathematics problem solving, then it is vital that both teachers and students use the role of visualisation clearly and use it to help them in their problem solving process.

Guzm'an (2011) states that:

> Visualisation is therefore extraordinarily useful in the context of the initial processes of mathematics as well as in that of the teaching and learning of mathematics. All this makes very clear the convenience of training our own visual ability and introducing it to those to whom we are trying to introduce mathematics (p. 31).

In an effort to make use of and improve learners' capacity to visualise, there is a need to focus on the importance and purpose of visualising and the visualising skill we would like them to improve. To achieve this, there is a need to understand what is meant by a visualising opportunity, avail that opportunity and come up with a language to talk about it.

In the light of this, Crapo (2000) identified the purposes of visualising to include, stepping into a problem, modelling and planning.

Just as it is important to understand the purposes and roles of visualising, it is equally important to understand the skills that support visualisation in problem solving. These skills will give us an insight into the ways in which we carry visualisation as we focus on the three purposes of visualisation earlier mentioned. The five skills that have been identified are internalising, identifying, comparing, connecting and sharing (ibid, 2000). The next section discusses mobile technology.

2.3 MOBILE TECHNOLOGY

2.3.1 What is mobile learning?

Mobile technology is defined in different ways by different authors. In an attempt to understand what mobile technology is, it is inevitable to explore the wider context of mobile learning, unpack its key components and interpret them under three concepts; the first component relates to mobility of the technology, the second to accelerated learner mobility while the third focuses on the mobility and dynamism of the learning processes and flow of information (El-Hussein & Cronje, 2010). Attewell & Savill-Smith (2005, p. 3) define mobile learning (or "mlearning") as learning by means of wireless technological devices that can be pocketed and utilised wherever the learner's device is able to receive unbroken transmission signals. Nyiri (2002) argues that mobile devices eliminate the fixity of traditional classrooms such as lecture halls, laboratories and other miscellaneous venues of traditional education. He adds that for many years, these traditional spaces have relied so much on static models of communication and devices for subject delivery. On the other hand, Traxler (2007), an advocate of mobile learning defines mobile learning as "wireless and digital devices and technologies, generally produced for the public, used by a learner as he or she participates in higher education." He adds, "Mobile learning as an educational activity makes sense only when the technology in use is fully mobile and when the users of the technology are also mobile while they learn."

Significantly, mobile devices are revolutionary since they transcend the restrictions of the structural stasis of classrooms and lecture halls and their related modes of communication, as they need not be confined to one particular place to be effective. El-Hussein & Cronje (2010)

sum it up as:

> The two terms under consideration are *mobility* and *learning*. On the one hand, "mobility" refers to the capabilities of the technology within the physical contexts and activities of the students as they participate in higher learning's institutions. On the other hand, "learning" refers to activities of the learning process, the behaviour of the learners as they use the technology to learn. It also refers to the attitudes of students who are themselves highly mobile as they use mobile technology for learning purposes (p. 76).

The evolution of portable handheld devices and wireless technology has given rise to radical changes in the lifestyles of people from both a social and an economic perspective. These devices are redesigning users' everyday lives in a number of ways. The next section discusses how mobile technology has been distributed in Zambia.

2.3.2 Mobile Distribution in Zambia

In my view, the potential of using mobile technologies in education is enormous in a country such as Zambia, as in other Southern African countries, where there is limited access to electricity and landline telephone networks, poor roads, limited or no access to reliable computers and few people with the necessary skills in using computers. As Traxler (2007, p. 2) notes, "mobile technologies in these parts of the world are a reaction to different challenges and different limitations, usually those of infrastructure, poverty, distance, or sparsity". In the midst of all these challenges, mobile phone coverage in Zambia is however very widespread compared to access to computers. As shown in Figure 2.1, below, the penetration rate of internet access is 24 percent, landlines 0.7 percent and that of mobile phones is 78 percent (World Statistics, 2015). Interesting to note is that access to internet for the majority of the people is through mobile phone.

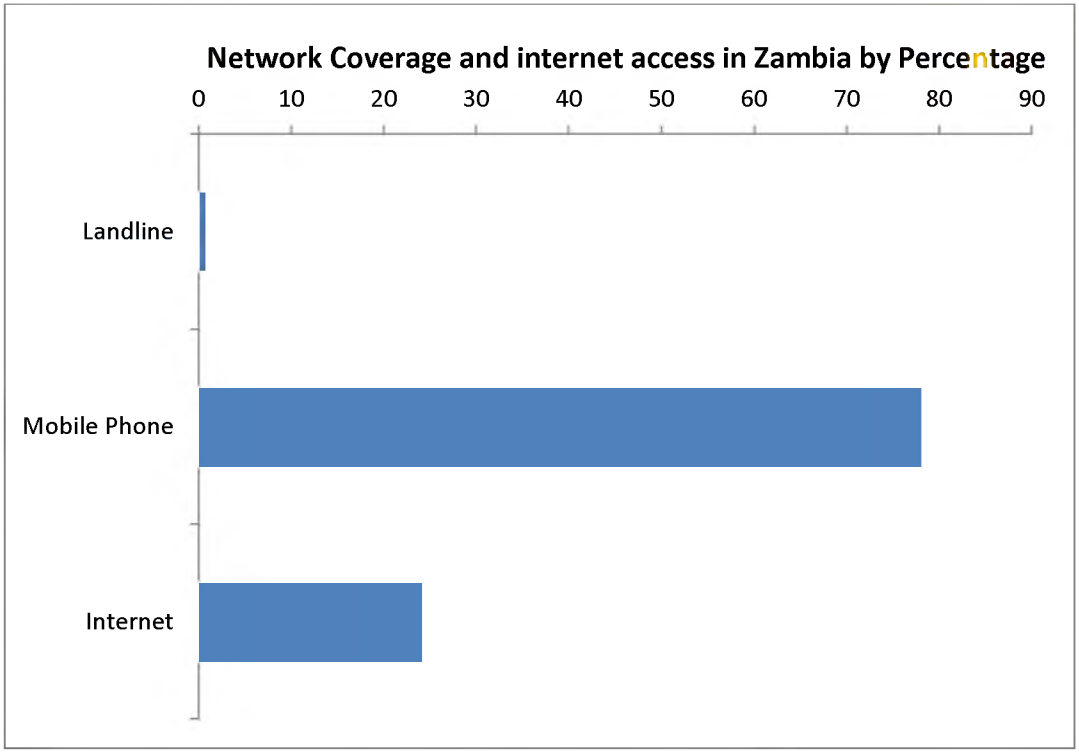


Figure 2.3.1 : Network coverage and internet access in Zambia by Percentage

Source: World Statistics (2015)

2.3.3 Education Value for Mobile Learning

The main function of ICT in tertiary education is to help the institutions with the provision of education, as learners are expecting "to use ICT to complement the inadequacy of teaching staff, learning and teaching resources and classroom space among other reasons" (Shuler, 2014, p. 82). This however does not imply that any new technology can be embraced out rightly in the teaching and learning process without thorough analysis of the nature of the technology and an investigation of the best methods suited for the implementation in a particular context.

One significance of learning mediated by mobile technology is to challenge the traditional dichotomous distinction between formal learning and informal learning by creating seamlessly connected learning experiences, adds Shuler (2014).

Gregarian, Hamwkins, & Taylor (1992) state that the "new technology per se is not a revolution, rather the revolution is the difference that teaching makes in how we organise, structure and empower our lives" (p. 7). Thus, ICT can be used as a mechanism for delivering in Higher Education (HE) courses for learning, and recognising the methods in which the specific technology can be used for teaching and learning is essential.

The current information era in which we are living is changing the culture of education. The use of information and communication technologies has given rise to new opportunities that are rapidly growing to embrace mobile technology, an evolution characterised as a paradigm shift from traditional learning. Mobile devices that include mobile phones are increasingly being used to recreate approaches and solutions to teaching and learning processes employed in traditional formats.

Hannafin & Land (1997) posits that technology-enriched learning can "provide interactive, complementary activities that enable individuals to address unique interests and needs, study multiple levels of complexity, and deepen understanding" (p. 168).

There are a number of factors that underpin the design for mobile learning in a specific context. Of significance, learning to use ICT should focus towards encompassing the learning potential and not just the use of ICT for its own sake (JISC, 2004b).

Mobile technologies today are pervasive as a medium for communication, and as such the feasibility of mobile technology to alter teaching and learning is overwhelming (Garrison & Anderson, 2003; Prensky, 2005; Kolb, 2008 as cited in Ndafenongo, 2011). Prensky (2006) posits that the 21st century, which is also referred to as the digital age, has brought a number of changes regarding technological devices and the expertise to effectively utilise them. In my experience most learners, who generally are young people, are very much at ease with using digital devices such as computers, video games, mobile phones and internet. This opens many educational opportunities and ultimately implies that teachers should consider realigning their ways of teaching to take advantage of this modern technology. Prensky (2006) recommends that the mobile phone, in conjunction with the computer, is one tool that could be effectively used in schools. Koebler (2011) concurs with Prensky and argues that it is logical to use mobile phones for learning and teaching especially in areas where there is a dearth of the latest technology.

Mobile technologies have the educational potential for the 21st century generation (Shuler, 2014). According to Shuler (2014), the opportunities that mobile technologies can offer to mobile learning include:

- Encouraging learning "anywhere, anytime"

  He states that mobile devices enable learners to gather, access, and process information in and outside the classroom and encourage learning in real-life contexts.

- Reach deserving learners

  Due to their relative low cost, mobile devices can be accessed by low-income communities, and use them to advance digital equity.

- Improve twenty-first century social interactions
- Fit with learning environments

  Due to their natural ability to easily fit into different learning environments, mobile technologies can overcome most challenges linked to bigger technologies
- Enable personalised learning experience

Shuler (2014) reiterates that mobile technologies have the potential to foster communication and collaboration, which are considered essential for success in the twenty-first century. Her views are echoed by Huang, Huang & Hsieh (2008) who acknowledge that the evolution of mobile devices has led to radical changes for people from both economic and social perspectives. According to Huang, Huang & Hsieh (2008) mobile learning attributes include:

- enhancing availability and accessibility of information networks;
- engaging students in learning-related activities in diverse physical locations;
- supporting project-based group work;
- improving communication and collaborative learning in the classroom;
- enhancing quick content delivery (p.3).

It is further argued that mobile devices can enable instruction to adapt to diverse and individual learners. Mobile devices offer important opportunities to support differentiated, autonomous, and individualised learning. These views are underscored by Jarvela, Naykki, Laru, & Luokkanen (2007) who reiterate that mobile learning offers the support for learning and training, and add that "mobile technologies have in some way contributed to support learners studying a variety of subjects" (p.71).

Planderleith & Adamson (2009) surmise that one of the roles of ICT is to assist learners to "refine, extend, and articulate the diverse range of skills they have developed through their experience of new and emerging technologies" (p.7), while Chickering and Ehrmann (1997) state that ICT tools provide deepened individual feedback as opposed to general feedback.

Though mobile devices have a number of positive features in the education dispensation, they are not devoid of negative aspects. These challenges can be categorised as cognitive, social and physical. Selwyn (2007) notes:

> Every technology used to convey meaning and used to communicate has its advantages and disadvantages. This inevitably implies that technologies are viewed from a perspective of what they can facilitate and what they can inhibit, as this will influence how meaning is constructed in order to foster learning (p.16)

While the benefits of ICT cannot be denied, there is still need to be mindful of the disposition of ICT for learning. Bould & Prosser (2002) stress that "Learning arises from what students experience, not what teachers do or technology does" (p. 237). With this awareness, there is need for higher education institutions to strike a balance.

Selwyn (2007) in a critical review of ICT in higher institutions revealed that some companies had a monopoly on hardware and software, which inhibited critical minds to be innovative. Oblinger and Oblinger (2005) argue that tertiary institutions should not "assume that more technology is necessarily better" (p. 2). They further state that the impact of teaching on teaching and learning outcomes should not only be credited to teaching, as the combined effect of technology and teaching is significant.

Those against mobile technology being used to enhance teaching and learning have outlined the following, among other factors, as major hindrances:

- **Cultural norms and attitudes**

Despite the belief by a number of experts that mobile devices have the potential to transform learning, there is a lack of conviction among parents and teachers. In a study conducted by Cooney (2014) at the Joan Ganz Cooney Centre workshop in collaboration with Common Sense Media, it was discovered that many teachers view mobile phones as a distraction and that they have no place in school.

- **Vague mobile theory of learning**

Currently, there is little consensus about a learning theory for mobile technologies and it is not given much significance in many schools. This inhibits effective pedagogy, assessment and new application designs for learning.

- **Differentiated access and technology**

The wide diversity of mobile technologies poses a challenge for learners and teachers in their attempt to hasten academic outcomes to facilitate learning in this environment.

- **Limited Physical Attributes**

Mobile technologies that are poorly designed can adversely affect usability and have the potential to distract students from learning goals. Additionally, the physical aspects of mobile technologies can hinder optimal learning experiences that include regulated text entry, small screen size, and limited battery life.

In her comparison between students who take advantage of mobile phones to those who do not, Vavoula (2009) found "indications that mobile learning is more interactive, involves more 'bustle', more contact, communication and collaboration with people" (p. 17).

The ability to personalise learning and the ubiquity across different contexts are key elements of mobile learning that set mobile learning apart from other learning environments. Its potential to "bridge pedagogically designed learning contexts, facilitate learner-generated contexts, and content (both personal and collaborative), while providing personalisation of ubiquitous and social connectedness that sets it apart from more traditional learning environments" was recognised by Cochrane (2010, p.134). Thomas (2005) is of the opinion that mobile learning could provide "flexibility, ubiquity of access to information, and motivating of increased engagement, and that mobile technologies and infrastructure facilitate this revolution of "always-on learning, accessible to the masses, but tailored to the individual" (p. 5). Traxler (2007) and Peters (2007) are of the view that finding information as opposed to knowing and immediacy are key components of mobile learning. Therefore, the common notion about mobile learning is that they are contextual, ubiquitous and personal.

These views have led the proponents of mobile technology to conclude that the positive impact of ICT in education outweighs the negative impact.

2.3.4 Mobile Technology and Visualisation

Visualisation, in particular dynamic visualisation, is a very important feature in "teaching for understanding" in mathematics because it aids the teacher by engaging learners in realistic situations (Makina, 2010).

Quite often, when thinking about learning scenarios, people usually revert to a mental image of the classroom with all learners facing the teacher. The supposition is that learning happens at fixed times and fixed places. Nonetheless, with the diffusion of technology, the concepts of place, time and space for learning have changed. The learning area is no longer demarcated by the 'classroom' but by 'learning' unconstrained by scheduled time or specific locations. With the mobile technologies at hand, students are capable of learning seamlessly, both in and out of the classroom, and both within and after school time. While learning can be facilitated by teachers or peers, at other times it could be student-initiated, spontaneous and emergent.

As technology advances, characteristics of mobile devices change rapidly, but important commonalities remain the same: portability, mobility and versatility. These functions make learning ubiquitous in and out of classrooms, provide potential opportunities for collaborative learning, and enrich the learning experiences with the support of technologies (So & Kim, 2008). In the next section, the VITALmaths project which produces the video clips used in this study is discussed.

2.4 VITALmaths

2.4.1 VITALmaths Project as a whole

VITALmaths (www.vitalmaths.com) is a multilingual collaborative research and development project between the University of Applied Sciences North-western Switzerland (FHNW) and Rhodes University in South Africa. The VITALmaths project produces short video clips specifically designed for the autonomous learning of Mathematics. Apart from English, the VITALmaths video clips are produced in isiXhosa and Germany.

The short video clips of about one to three minutes in length are usually produced using natural materials with a view to developing different mathematical ideas and processes. Linneweber-Lammerskitten, Schafer, & Samson. (2011) emphasise that "it is envisaged that these video clips can then be used in the preparation of lessons, for personal conceptualization of mathematics concepts and as motivational and explanatory tools, with the emphasis lying on teachers and learners to use them as autonomously and independently as they wish" (p. 356). There are a number of video clips produced on various mathematics topics in this project, but the VITALmaths video clips considered in this study are only on three topics: Consecutive Odd Numbers, Rectangular Products and Palindromic Sums.

Uploading these clips on mobile phones to be used as a visualisation tool would not only promote qualitative learning and teaching but would also reach out to many learners. This is especially the case in the African setting where the mobile phone has become so ubiquitous, that its penetration levels in some countries have exceeded hundred per cent. This is due to the fact that some individuals own more than one registered handset.

The VITALmaths project, which produces the said video clips to be used in this study, emphasises the importance of autonomous learning (Linneweber-Lammerskitten., & Schafer, 2010). I wish to use the mobile phone as a conduit for an environment where learners navigate, explore and deliberate with the content of the video clips at their own pace. It is common knowledge that a mobile phone is not only a gadget for communication but also a tool that can perform many other functions. These features among others include, taking pictures, recording and playing sound and visual files, sending and receiving text, downloading and uploading different media, accessing data both offline and online. The

focus of the VITALmaths project is putting technology in learners' activities into practice, so that learners may engage with the topics as active participants.

These video clips can be freely accessed from the website: www.vitalmaths.com.
In my view, VITALmaths can be said to be a product of finding effective ways of sharing innovative practice in technology-enhanced learning.

2.4.2 Videos

According to Bitter & Pierson (2002), video can bring content to life. Among other attributes, it can also

- bring distant, imaginary, or simulated places into the classroom
- Bring history to life
- Reinforce instruction

Furthermore, since video recordings are asynchronous, they are an ideal choice for schools as they can be paused and played back for clarity at times convenient to the students, and can easily be scheduled into classroom time.
It should however be pointed out that the video in education can have its negative aspect. Cohen et al (2011) point out that video, if not properly used, can also disengage learners and encourage passive learning.
In this study, the video recordings will help explore the behaviour of the participants while the video clips on mobile phones will be used to support learning in reference to the theoretical framework that informs this study.

2.5 TEACHER EDUCATION AND THE ZAMBIAN CONTEXT

2.5.1 Curriculum (Visualisation and Technology)

Primary and Secondary schools in the Zambian Education system can be divided into four types: Government (public schools). Private, Grant-aided and Community schools. In terms of performance, research has revealed that private schools had the highest overall mean performance, followed by grant-aided schools, then government schools and finally community schools (Zambia. Central Statistics Office [CSO], 2010).

The Zambian curriculum is currently undergoing review, aiming to design a curriculum that is relevant to the needs of the people in line with Vision 2030 (Ministry of Education, 2014). The review is being undertaken by the Ministry of Education (MOE) under the auspices of

the Curriculum Development Centre (C.D.C). It has been emphasised that (Zambia. MOE, 2014, p. 15):

> The review was necessitated by the need to provide an education system that would not only incorporate the latest social, economic, technological and political developments but also equip learners with vital knowledge, skills and values that are necessary to contribute to the attainment of Vision 2030.

The syllabus has been reviewed in line with the Outcome Based Education principles which seek to link education to real life experiences that give learners skills to access, criticize, analyse and practically apply knowledge that help them gain life skills (Zambia, MOE, 2014). It is also hoped that the review will help improve students' performance especially in Mathematics, in which learner performance has been below average from primary to tertiary education (ibid, 2014).

Methods of teaching that do not promote conceptual understanding was cited as one of the reasons for poor performance in the Zambian mathematics education system (Zambia, ECZ, 2014). It was noted with regret that emphasis in the interaction with student teachers in Colleges of Education, is more on methods that promote rote learning and procedural understanding. The teaching methods that should sufficiently expose student teachers to conceptual understanding and the construction of knowledge are unfortunately not given much attention. Anecdotal evidence suggests that tutors attribute the reasons for not emphasising on methods that promote conceptual understanding to "preparing students for examinations" and therefore focus is more on completing the syllabus.

Research conducted by the National Assessment Survey (NAS), has revealed that teacher performance has however remained relatively good over the survey years with a marginal drop in mean performance in mathematics during the 2014 Survey (Examination Council of Zambia [ECZ], 2014). The positive development for the teachers at primary school level could be that they possess the knowledge content of the various subject areas. However, transmission of the knowledge to their pupils remains a challenge as observed from the overall mean performance with their learners. The kind of transmission earlier alluded to is said not to promote conceptual understanding (Zambia. MOE, 2014).

One way in which conceptual understanding can be enhanced is by integrating appropriate technology in the teaching and learning process. The use for example, of a mobile phone, a

device that is pervasive among student teachers in Zambia and has the potential to be used as a visualisation tool, could be one of the solutions.

In an effort to help learners' comprehension of concepts, the Zambian Revised Curriculum acknowledges that teachers should use a variety of appropriate materials as this will help them in visualisation (Zambia. MOE, 2014) and this is being taken into consideration in the current curriculum review.

One major issue that has come up in the curriculum review is the two-career pathway. This is a deliberate policy that takes note of learners' strengths, at an early stage, in the academic or vocational paths. The learners who exhibit strength in academic-inclined subjects are given subjects that are inclined to academics, while those who are inclined to vocational ones are given subjects of a vocational nature. This has further been necessitated by the fact that the formal sector is unable to absorb a significant number students graduating from tertiary institutions. It is hoped that those who take the vocational route would easily fit into the informal sector.

The curriculum revision also focused on changing the language of instruction so as to promote the teaching of local languages in lower grades. There was also re-orientation of both the primary and secondary school components of the curriculum so as to place more emphasis on life skills.

Ministry's resolve to implement the Revised Curriculum is very explicit: "commitment to the implementation of this curriculum should be demonstrated by sufficient provision of resources to the institutions of learning," (Zambia. MOE, 2013). In my view, one such resource could be mobile technology.

MOE also embarked on a robust programme to develop teaching and learning materials that were specifically aligned to the Revised Curriculum.

The objectives of the Zambian education sector for the period 2011 to 2015 have been guided by the broader objectives as outlined in both the Sixth National Development Plan (SNDP) and the National Implementation Framework – Three (NIF III) (Zambia. MOE, 2015p. 2). Resulting from the above, the following are the objectives of the Ministry during the lifespan of NIF III from 2011 to 2015:

- to increase access, efficiency and equity to quality ECE and Primary Education

- to increase access, efficiency and equity to quality Secondary School Education
- to increase the number of qualified and competent teachers in schools
- to increase access to science, technology and innovation
- to increase access, participation and equity in the provision of quality university education
- to increase efficiency and equitable access to quality TEVET training
- to increase Adult Literacy levels
- to expand and improve infrastructure
- to review the curriculum at all levels to make it relevant and responsive to national aspirations and education needs
- to integrate the Information and Communication Technology (ICT) in the education system, leading to the development of appropriate local ICT products and services (MOE, 2015, p. 2).

From the objectives above, it is evident that the MOE had embarked on the provision of a holistic education to the Zambian people, in an attempt to better the provision of education at all levels both quantitatively and qualitatively. While quantitative aspects of educational service provision would be addressed through accelerated expansion of classroom space, quality aspects would be addressed by equipping teachers and schools with requisite skills, equipment and facilities that are critical to effective learning. Human resource development through education and training is one of the priorities under the Sixth National Development Plan through NIF III (Zambia, MOE, 2015).

Important to note is that in the broader objectives of MOE outlined above, the tenth objective is on integration of ICT in education. ICT is the broader domain in which the study on VITALmaths project lies, which in my view underscores the importance of this study.

Despite marginal gains in the mean performance of teachers being recorded, the quality of education in terms of learning achievement in Zambia has remained low, as revealed by the assessment results (Zambia. MOE, 2015). Learning achievement levels at primary school level have remained stagnant since the first survey in 1999, as only 30 percent of the learners at this level are meeting the set levels of proficiency in English Reading, Mathematics and Life skills (MOE, 2015). The poor learning achievement levels, set against the exponential growth in enrolments, have been said to have masked even the little gains that could have been made in terms of quality. This fact can be cited from the low levels of learner achievement in both formative test results and the summative examination results.

Learners from Government schools have predominantly been the principal victims of the scourge (ibid, 2015). Preliminary findings in NAS, 2014 have further confirmed the above phenomenon in the education sector.

For instance, the Mean Performance in the 2014 Survey recorded a drop in English, Mathematics, Zambian Languages and Life skills, as compared to the 2012 survey. The average performance of all learners fell below the pass mark of 40 percent in all the four subjects (Zambia. ECZ, 2014).

One solution to the above challenge could be striking a balance between inputs and interventions into education quantity improvement, and those that are channelled to address quality issues, which could include visualisation and technology, in the sector.

In an attempt to improve learning outcomes, another measure taken by the Ministry of Education (MOE), through its implementing agency, the Examination Council of Zambia (ECZ), has been conducting National Assessment Surveys since 1999 in the four critical areas of English, Mathematics, Life skills and Zambian Languages (Zambia. MOE, 2015). A National Assessment Survey is "a process in which information is gathered for the purpose of monitoring the functioning of the school system as a whole. It is a comprehensive and systematic approach to how the school system is performing in terms of its principle outcome - pupil learning" (ibid, 2015, p. 1). This is an attempt to assess the competencies of Grade 5 learners and their teachers in these subjects, identify problem areas and suggest remedial action.

Another consistent feature of the NAS results has been the insistent indication that levels of learning achievement at the primary level in Zambia have not been satisfactory, with only marginal improvements if any. This was an indicator for MOE to realise that something was really wrong with the manner in which the Zambian Education system is performing.

In order to remedy the situation, there is need to formulate and implement sustainable interventions that would help in mitigating the identified gap in education quality and provision. It is hoped that recommendations from the surveys will effectively inform national policies and feed into various national programmes aimed at remediation as well as strengthening measurable pedagogy in the classroom.

The findings of the survey also provide valuable information for policy issues, which have been cardinal in the Zambian curriculum review of 2015. However, for the purposes of this study the focus will only be on numeracy.

MOE, in conducting these surveys, has established its determination and resolve to effect a paradigm shift to focussing on qualitative issues of education provision rather than those of quantity. This has contributed valuable insights that have initiated policy changes in the education stance and delivery.

In the National Assessment Survey conducted by the Ministry of Education, one of the recommendations was to focus on curriculum quality in the entire education system (Zambia, MOE, 2015).

Zawacki-Richter, Brown, & Delport (2007) postulate that the use of technology in the teaching and learning process results in enhanced cooperative learning, integration of the curriculum, and application of appropriate strategies for "global learners". On the other hand, Oliver (2002), views ICT implications from a perspective of where and when students learn. He holds that by learning where one is not confined to the lecture room, opportunities are provided for "just-in-time" learning for students.

Previous research on mobile learning mostly focussed on either formal or informal aspects and did not examine the integrated and synergetic effects of the link between these two contexts (Sharples, 2006). With the increasing pervasive and ubiquitous nature of mobile learning, a point has been reached where students are able to possess these tools and use them in settings that are both formal and informal.

A gap however exists in research between the two settings; there is a need to bridge this by choosing a learning environment and conducting longitudinal studies to investigate the affordances of this learning environment, thereby fostering 21st century skills, knowledge and positive attitudes towards learning.

As has been emphasised from the beginning of this study, one of the strengths of visualisation lies in problem solving. However, what is generally common among learners in Zambian schools is that they may solve a mathematical problem quite well but fail to relate it to real life situations. The teaching and learning process tends in most cases to be too theoretical and formulaic, and in an attempt to mitigate this, visualisation could become a powerful and important tool in the Zambian educational context in general and in mathematics education in particular. This is so because of the potential of visualisation to model different types of problems, its ability to engage learners in the processes of reason, and its engagement in higher-order thinking centred on problem solving. Furthermore, through visualisation, it is possible to use other methods such as brainstorming, enquiry learning and tools such as Geogebra. Additionally, visual narratives using animation and

other technological tools can provide effective tools to use visualisation in collaborative ways.

However, despite the general bleak picture in the Zambian education system especially from a qualitative perspective, some positive aspects have been recorded in other areas. According to IOB (2011), the performance indicators at the primary school level in some areas can be said to have been favourable specifically between 2012 and 2014 as indicated below:

- The number of schools increased from 8359 in 2012 to 8754 in 2014 representing a growth of 4.7 percent.
- The enrolment figure stood at 3,135,442 in 2012, this dropped to 3,075,161 in 2013, and in 2014, the figure increased to 3,217,872, representing a rise of 4.6 percent.
- The completion rate in 2014 at Grade 7 level was 86.2 percent while at Grade 9 level, the completion rate stood at 57.9 percent and 31.7 percent at Grade 12 level.
- The transition rate from grade 7 to 8 showed steady improvement between 2011 (59.9%) and 2012 (64.2 %). However, the rate reduced to 61.9 percent in 2013 and in 2014, dropped further to 59.3 percent.
- Gender parity remained favourable at 0.99 in 2014. Currently about 14% of Grade 1 entrants have Early Childhood Experience (ECE) experience. National mean performance in reading in English, Mathematics and Zambian languages remains below the desired minimum average of 40%.
- In terms of certificate pass at grade 7 between 2012 and 2014, improvements were observed in the proportion of learners attaining divisions 2 and 3, implying that more learners were being pushed from the lower end, which is division 4, into divisions 2 and 3, an indication that performance at the lower end is improving (p.15).

As the Education for All (EFA) and Millennium Development Goals (MDG) period comes to an end, indications are that Government is committed to infrastructure development and human resource development with a focus on education and skills development.

With the era of EFA having ended in 2015, the focus in the post-2015 agenda has shifted to equity and quality education, the teacher, girls' education and other equity interventions (MOE, 2015). The debate on the world platform indicates that the post-2015 global education agenda would overall focus on skills acquired through education for global citizenship and sustainable development. This is in tandem with the national aspirations for education as espoused in the Vision 2030 (MOE, 2015).

2.5.2 Teacher Training

The teaching and learning process is increasingly becoming a major challenge in sub-Saharan Africa, and Zambia is no exception (MOE, 2014). MOE (2014) adds that among the major challenges faced by the education sector in Zambia from early childhood to tertiary education are: under-qualified teachers, the inclusion of an insufficient number of mathematics- and science-related subjects especially at higher levels, and a lack of appropriate education materials to support the teaching of numeracy and mathematics in schools (p. iii). Kelly (1999) notes that one major contribution to the poor performance by pupils in Zambia in school certificate examinations is the perennial unsatisfactory results in school mathematics examinations. Furthermore, Educating Our Future, Zambia's National Policy on Education, asserts that a number of challenges faced by many learners in mathematics have their roots anchored in the manner the concepts were introduced at primary school (Zambia. MOE, 1996).

Today's learners live in a digital world where the use of technologies such as instant messaging, picture and video sharing, and tools for social networking are an integral part of their lives. One technological device on which all these and others services can be provided without a person being restricted to one geographical spot is the mobile phone. The mobile phone has become pervasive and ubiquitous among learners especially among relatively young learners, of which student teachers are a part.

Research into unified learning needs a robust focus on pedagogy, professional development of teachers, lessons co-designed with teachers, a design research perspective and affordable mobile learning devices (Hawkins, 1997). Hawkins (1997) adds that collaboration and innovation can contribute towards the broader research agenda. By collaborating globally, researchers could take advantage of different student teachers' device preferences, and exchange curriculum ideas.

In research on the impact of technology in education, consensus is growing globally that focus should not be on teaching technology itself but rather on the affordances of the technology in education (Clark, 1994). This can be attributed to one fundamental challenge for the 21st century learners, which is not only what they learn, but also how and when they learn.

The role of teacher education in the midst of the relatively new ubiquity of mobile devices in the Zambian environment have imbued the mobile device with new meanings. With the advent of mobile technology, the mobile phone has the potential to present teachers with a more sustained and interactive method of teaching. Looi (2009) affirms that:

> The portability and versatility of mobile devices has significant potential in promoting a pedagogical shift from didactic teacher-centred to participatory student-centred learning. In this type of learning culture, a teacher acts as a facilitator and learning partner rather than a sole expert of knowledge.

Bates (2005) maintains that usually new technologies are unfamiliar and there is therefore a need to understand their different forms with a view to exploring situations that are appropriate for effective teaching and learning. While appreciating that different technologies provide different affordances in the learning process, they should nonetheless be utilized selectively, to optimise students' learning. This is due to the fact that not all technology can successfully be used in the teaching and learning process, hence the need for research to investigate opportunities that can be provided not only to create new kinds of teaching, but also to support students' learning.

In an effort to highlight the learning achievement levels among Grade 5 learners at primary school level in Literacy, Numeracy, Life skills and Zambian Languages, the Ministry of Education (MOE), through its implementing agency, the Examination Council of Zambia (ECZ), launched the National Assessment Survey (NAS) in 1999. Trends in Mathematics national performance since 1999 have remained as shown in figure 2.5.1.

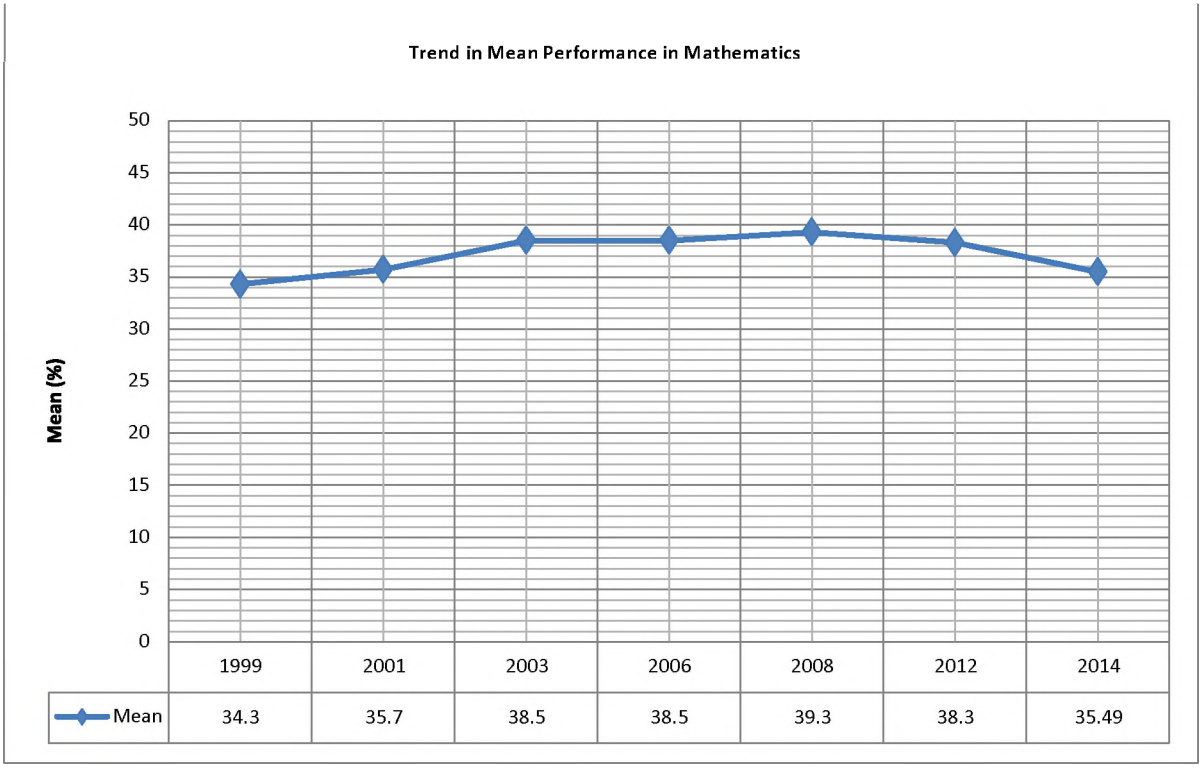


Figure 2.5.1: Trends in National Mean Performances in Mathematics over Survey Years

Source: Zambia. MOE, (2014)

The analysis of this graph shows that while there was a steady increase between 1999 and 2003, there was no improvement in Mathematics performance over the period between 2003 and 2014. Additionally, the 2012 and 2014 Survey Reports show a downward trend in the national performance. This could suggest that there is very little teaching and learning, that promote conceptual understanding, being undertaken in schools.

Furthermore, at an international level, Zambia's performance in mathematics, as indicated in the Southern and Eastern African Consortium for Monitoring Education Quality (SACMEQ), is of great concern. Zambia was the lowest ranked among 15 countries in the SACMEQ 2011 Mean Reading and Mathematics survey as shown in figure 2.5.2.

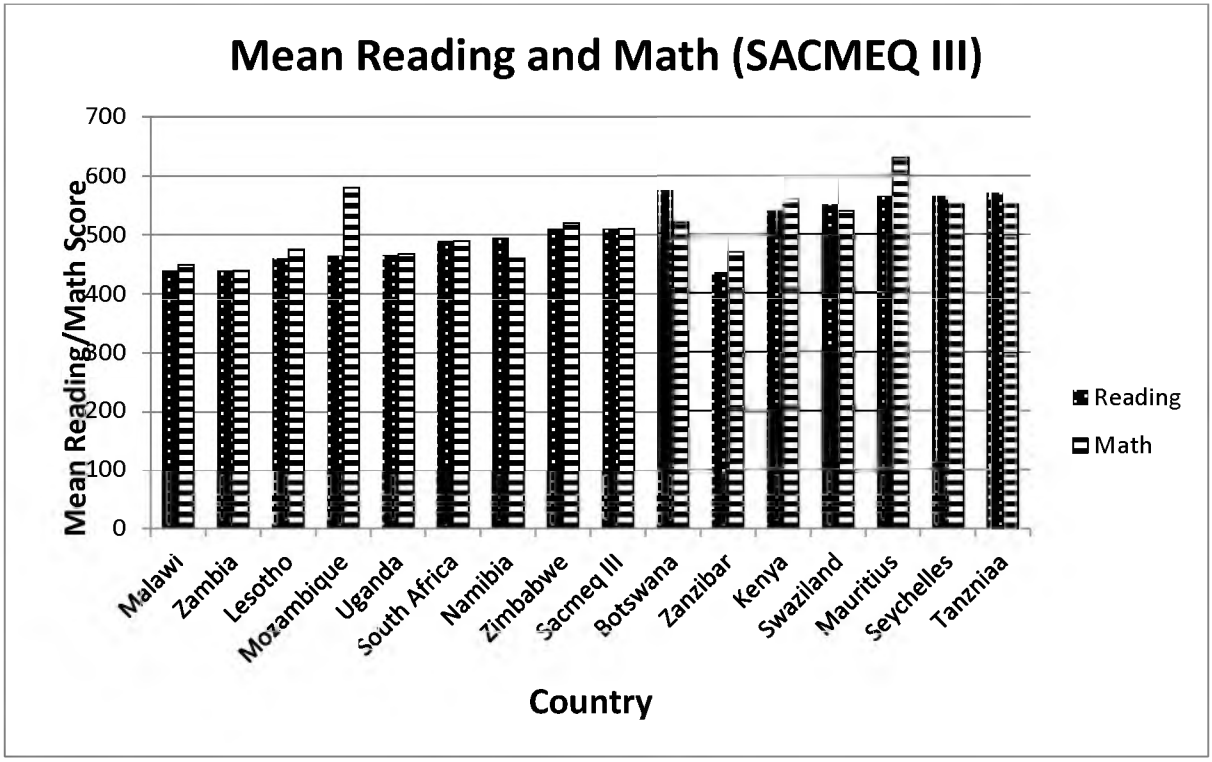


Figure 2.5.2 SACMEQ III (2012) Mean Reading and Mathematics

Source: Zambia. ECZ , (2012)

In Zambia, as the focus shifts from achieving access to primary education to quality of education, there comes the need to hold schools accountable for the performance of their learners.

This poor performance is further corroborated by the Provincial results, which indicate that Zambia's performance has remained below the minimum desired level in each subject.

This scenario is reflected in the Provincial Mean Scores across the country, which were between 33 and 39 percent, with the National Mean being 35.59 as indicated in figure 2.5.3 below:

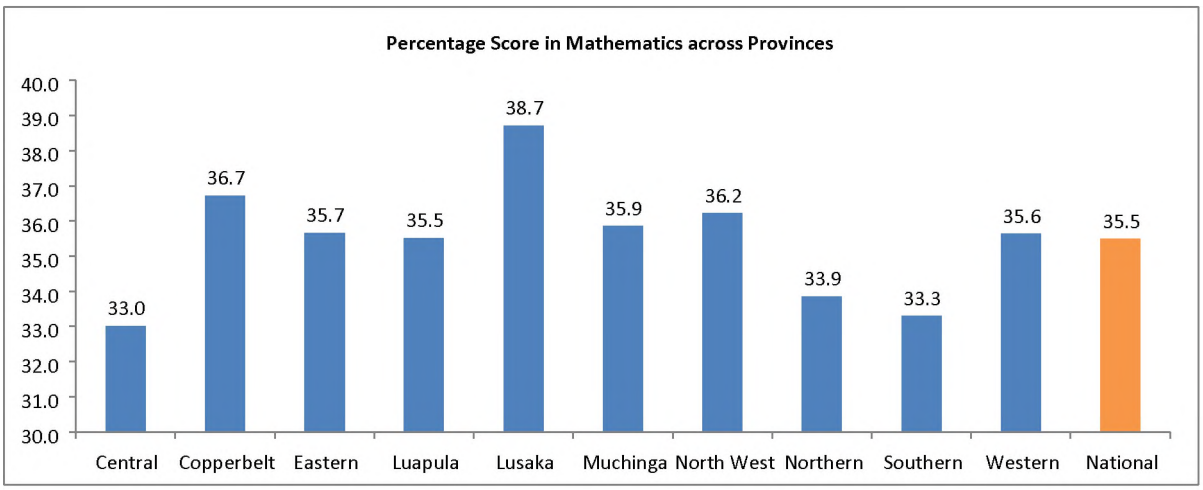


Figure 2.5.3: Provincial Mean Scores across Provinces

Source: Zambia. MOE, (2014)

It is evident from the above information that performance in Mathematics overall has remained low throughout the years of the National Surveys.

In dealing with problematic areas, teachers are encouraged to devise ways of teaching learners elementary mathematical concepts effectively. This will promote a holistic approach to education that would go a long way to ensuring that quality education is attained.

2.5.3 Student Teachers (Colleges of Education and Other Teacher Training Institutions)

On the synergy between mobile technologies and learners, JISC (2005) point out that mobile phones are part of modernity and that "tools for learning in the 21st century institutions need to reflect on changing expectations of how, when and where we learn (JISC, 2005, p.26). Using a mobile phone as a conduit to provide learning activities has the possibility of engaging the students in higher education institutions. Kukulska-Hume (2005) identified three main reasons for higher education institutions to embrace mobile learning and these are: (1) improving access to education (2) exploring further potential for teaching and learning by improving learners' access to learning and (3) Institutional policy alignment.

Petit & Kukulska-Hume's (2007) study analysed how mobile technologies interweave with students' daily life practices especially when they are in transit. Studies on the use of mobile phones attest to pervasiveness; students at higher education institutions use their mobile phones to make calls, send messages, take pictures, and make videos (Kennedy et al., 2006). Suffice to say that a mobile phone is a personal tool through which different types of media can be communicated.

In her comparison between students who take advantage of mobile phones and those who do not, Vavoula (2009) found "indications that mobile learning is more interactive, involves more 'bustle', more contact, communication and collaboration with people" (p. 17).

John & Sutherland (2005) suggest that in order for a tool to be more effective in a learning process, it has to be discernible as a learning tool and not necessarily as a mediating tool. This implies that a tool ought to be familiar to the user and be taken naturally as part of their day-to-day life. This is basically what a mobile phone is to the majority of student teachers in Zambia.

In the study of Conole et al. (2008), it was found that there are changes in the way students are learning with ICT. The aspects of ICT usage in learning that they found were: (1) Pervasiveness: students' use of technology to support most of the aspects of study. (2) Utilitarian use: students being members of committees of practice where they ask for help and share resources. (3) Personalised usage of ICT: Use of appropriate technologies to meet students' needs of interactive and multifaceted learning. (4) Management of learning: accessing information easily. (5) Transferability: transferring practice of use of technologies in various aspects of life in the learning context. (6). Time: fragmentation of learning and expectation for latest information. (7) Changing work patterns: methods of gathering, use and creating of knowledge with conformity to technology. (8) Integrated: use of different tools, content and media appropriate for learning needs (p. 35).

They recommend that, due to some or all of these aspects, ICT should be used in the teaching and learning process in teacher education institutions.

One thing that needs consideration in seamless learning research with mobile devices is an understanding of the enactment of learning activities that unfolds in various situations. Previous research that scrutinized the use of mobile devices in informal settings has shown both promises and challenges (Chen & Kinshuk, 2005; Sharples, 2006; Squire & Kloper, 2007). Mobile technologies with portability, connectivity and versatility enable learning to be pervasive in and out of classrooms, provide potential opportunities for collaborative learning, and enrich learning experiences with the support of technologies. For instance, Rogers et al (2004) recommend that mobile devices could be used to help students explore digitally augmented physical environments where contextually relevant information and resources are provided. In such digitally enriched settings, students using mobile devices could explore, capture and manipulate both physical and virtual objects for active understanding.

However, mobile learning in informal settings is challenging because students are 'on the move' across different modes of space- physical and virtual-and time. Therefore, an ethnographic approach (Anderson-Levitt, 2006) can be integrated into research to observe how students are engaged in informal and formal learning settings in their interaction with their handheld devices, peers, teachers and other people in their learning community (Barron, 2006; Squire & Klopfer, 2008).

2.6 THEORETICAL FRAMEWORK

2.6.1 Constructivism

ICT has a role to play in the factors designed to foster learners' engagement on the principle that learning influenced by an individual's participation in activities is educationally purposeful. The Australian Survey of Student Engagement Report (2009) contends that while students are expected to construct knowledge, learning is also dependent on staff and institutions creating conditions that motivate and encourage involvement. The need for the effective use of technology and not merely using technology for technology's sake was one of the findings from the National Union of Students (NUS) (2010) report. Another finding was that ICT can benefit teaching, but reaching its full potential is a challenge.

In order to design a sustainable 21st century learning environment, researchers need to make a commitment to conduct sustained research (Nardi & Schwarz, 2002), and this requires theoretical and methodological lenses congruent with the research (Wittrock, 1977).

One theoretical aspect that is of primary significance to mobile learning is social constructivism. Constructivism is a theory of knowledge that suggests that human beings generate knowledge and meaning from interactions between their experiences and their ideas (Piaget, 1967). These experiences relate to everyday life and various communications and interactions that human beings engage in. The nature of these engagements varies greatly and includes interactions with others on social media using mobile technology devices. Giesen (2004) reiterates that constructivism is a theory of learning which states that people create their own understanding and knowledge through experiencing things and reflecting on those experiences. From a constructivist perspective of learning mathematics, learners construct their own mathematical knowledge as opposed to receiving it as a finished product from a textbook or a teacher (Perry, Geoghegan, Howe, & Owens, 1995).

Hannafin (1992) holds that learning is not achieved by "mastery of formal knowledge as such, but rather by activities that progressively refine and quantify relationships among connected elements" (p. 54).

Learning activities should therefore engage learners in meaningful opportunities and appropriate tasks so that the learners can see the direct implications and apply the gained knowledge in their context (Wilson & Cole, 1996 and Dabbagh, 2005). As noted by Olivier et al. (2002), learning is "achieved by the active construction of knowledge supported by multiple perspectives within a meaningful context" (p. 496).

Wilemsky (1991), Hannafin & Land (1997), and Bennet et al. (2007) contend that rich hands-on involvement through personal links of ideas, context and perspectives results in learning that is meaningful. Activities optimise learning experiences; therefore, the learning environment needs to offer a structured context rich in providing opportunities to engage in knowledge construction.

Pappert (1990) is of the view that learning is developed through activities. Oliver et al. (2007) echoes this by stating that learning activities are a "deliberately planned set of experiences that are intended to help learners to learn" (p. 65). Qiao, Sun & Wang (2009) add that a learning activity is an "interaction between a learner and an environment that may also involve other learners, resources and services to achieve a planned outcome" (p. 127). Beetham (2007) further adds that a learning activity is an interaction between the environment and learners using certain selected tools towards an outcome.

Chickering & Ephraim (1997) contend that effective use of ICT in higher education institutions facilitates interaction among tutors and learners for collaborative problem solving. This accords students an opportunity for engagement where students construct knowledge as opposed to merely receiving information.

Hannafin (1992) holds that learning is not achieved by "mastery of formal knowledge as such, but rather by activities that progressively refine and quantify relationships among connected elements" (p. 54).

As noted by Olivier et al. (2002), learning is "achieved by the active construction of knowledge supported by multiple perspectives within a meaningful context" (p. 496).

Hannafin & Land (1997) posits that technology-enriched learning can "provide interactive, complementary activities that enable individuals to address unique interests and needs, study multiple levels of complexity, and deepen understanding" (p. 168).

2.6.2 Constructivism and Visualisation

By its very nature, mobile technology is a significant feature in most activities of young people, including teachers, as they work collaboratively and share information. It is this activeness that develops with mobile technology that is cardinal in adopting mobile learning as a learning environment. Teachers' use of technology to enhance visualisation has the potential to engage learners in active mathematical practices that include experimenting, investigating and problem solving which can add depth to understanding (Goos, 2010).

Sharples (2002) argues for personal learning mediated by mobile technology through a social constructivist discourse. This should encompass learning supported by both mobile devices such as mobile phones and portable computers (p. 180). It is envisaged that a mobile phone, with its high adoption rate and use among student teachers, can improve classroom dynamics due to its data connectivity that fosters social interaction (as advocated by constructivism) and collaboration (Low & O' Connel, 2006).

Ndafenongo (2011) contends that naturally, mobile technology is key in a number of activities in the lives of young people as they work collaboratively and share information (p.24). He cites examples of activities such as texting, graphics, and passing on information, and adds that it is such human interaction and the nature of knowledge that develops as learners engage with mobile technology. This is cardinal in adopting a learning environment such as mobile learning.

2.6.3 Constructivism and Teacher Practice

There will be instances where learners can engage in self-learning resulting in discovery, and at other times when they interact with others, such as their peers, teachers or experts. In such scenarios, learners may create digital products with mobile devices, which they share, modify, use to build upon existing products, and integrate together. This may result in creating new knowledge, facilitating knowledge construction and social discourse, as well as mediating interaction among a community of learners (Stahl, 2000).

2.6.4 Constructivism and Teacher Technology

The role of digital technologies needs a transformative role. Hannafin & Land (1997) agree, "Technical capabilities should not dictate how much learner control is supported, but how much is possible. They determine not what should be, but what could be" (p. 176). Therefore, there is need to promote new ways that will assist the learner creatively in the awareness of how technology could be used in various settings. Hannafin & Land (1997) maintain that one challenge for learning is to "capitalise on the capabilities of engaging

technologies based upon existing designs, while generating new designs rooted in emerging psychological and pedagogical research and theory" (p. 76).

Dunlop and Grabinger (1996) and Passey (2010) suggest that through the provision of a variety of learning activities, meaningful learning can be achieved.

Warger & Dolbin (2009) define a learning environment as "the totality of the surroundings & conditions in which something or someone functions" (p. 6). Olivier et al. (2007) define learning environments as "learning settings that support knowledge construction, the emphasis is placed on learning as a process of personal understanding and development of meaning in ways that are active and interpretive" (p. 497).

A variety of technologies can be used as tools that students can select as a way of engaging with peers and tutors in constructing learning. Evan and Abbot (1998) reported that "the new look" veers more towards individualised, participatory active learning" (p. 46). Collins and Moonen (2005) emphasise that students should move away from the notion of Higher Education as an acquisition of knowledge process, to one that perceives knowledge acquisition as a learning environment with students participating and contributing more effectively. One way of achieving this is by using technology to help students' engagement in their learning environment. There is therefore a need to capitalise on the affordances of ICT applications such as videos on mobile phones to support student teachers' learning. The learning activities designed for mobile phones should thus be learner centric, collaborative, contextual and engaging. The mobile phone can help eradicate boundaries between students' daily life and experiences and their school life to ensure efficiency in teaching and learning.

Previous research on learning with mobile technology has clearly shown that the mobility and connectivity of technological tools enable a student to become an active participant, not a passive receiver in learning activities. For instance, instead of sitting in front of a desktop computer and watching a video simulation, students with mobile devices can go out into the field, directly and physically explore the world, and share their experiences with others (Colella, 2000; Roschelle, 2003; Squire & Klopfer, 2007).

This however does not imply that abstract knowledge and media-replicated experiences have no room in the learning processes, but one major challenge in traditional schooling practices is the excessive level of decontextualized information, indirect and abstract knowledge, and experiences in classroom contexts (Barab, 2002). The next section discusses Number Sense which is the mathematical domain of this study.

2.7 NUMBER SENSE

2.7.1 Definition of Number Sense

Number Sense has been recognised as central to young children's development of prowess in mathematics for a number of decades (Australian Education Council, 1990; National Council of Teachers of Mathematics [NCTM], 2000; Sowder, 1988). Different authors have defined Number Sense in different ways. Bobis (1996) defines number sense as "a well organised conceptual framework of number information that enables a person to understand numbers and number relationships and to solve mathematical problems that are not bound by traditional algorithms". On the other hand, Burton (1993) and Reys & Yang (1998) refer to Number Sense as a person's general understanding of numbers and operations along with the ability to use this understanding in flexible ways to make mathematical judgments and to develop useful strategies for solving complex problems.

2.7.2 Characteristics of Number Sense

Number Sense has a number of important characteristics. These include the ability to reason, think flexibly and understand relationships, which are fundamental aspects required in all spheres of mathematics, from simple arithmetic to complex mathematics (Gersten and Chard, 1999). Kalchman, Moss, and Case (2001) observe that the characteristics of good number sense include: fluency in estimating and judging magnitude; ability to recognize unreasonable results; flexibility when mentally computing; ability to move between different representations and to use the most appropriate one (p.2).

Five components that characterise Number Sense were identified by the National Council of Teachers (1989):

- Number meaning
- Number relationships
- Number magnitude
- Operations involving numbers
- Referents for numbers and quantities

2.7.3 Importance of Number Sense

Bobis (2008) postulates that without a strong foundation in Number Sense, it is difficult to carry out even the most basic everyday mathematical activities. She contends that building a strong number sense will greatly help to equip learners to face mathematical challenges in future.

2.7.4 Number Sense in the Zambian Curriculum

According to the Zambian Education Curriculum Framework (MOE, 2014), number sense is an integral part of numeracy. It further explains that Numeracy is the ability to reason and to apply simple numerical concepts usually taught at lower levels and that it forms a foundation for higher mathematical skills at higher grades (p. 3).

2.7.5 Number Sense and Visualisation

Research has indicated that Number Sense develops gradually and over time resulting from an exploration of numbers, visualizing numbers in a variety of contexts, and relating to numbers in different ways (Burns, 2007).

In her study that investigated aspects of the relationship between number sense and visualisation, Bobis (2008) observed that many children lacked a good 'sense of number' despite having been exposed to formal mathematics schooling. She noted that this contributed to the recognition by researchers of the importance of studying young children's visual representations of numbers in their attempts to explore their earliest understandings of number concepts. It was further noted that activities that focused on the visual identification of groups of numbers, such as subitizing (emphasis mine) rather than counting one-by-one helped learners develop understanding of part-whole relationships, especially in the decomposition of ten (*ibid*, 2008). She contends:

> Given that many children lack a well-developed Number Sense after being exposed to traditional teaching, it is crucial that alternative methods be explored. While counting is important, it does not allow children to develop a rich variety of number relationships. Visualisation at a young age gives children these additional skills (p. 1).

2.8 CONCLUSION

The purpose of this chapter was to provide a contextual background to this study.

Firstly, the role of visualisation in mathematics was discussed. This was followed by a discussion on mobile technology and its educational value and thereafter the VITALmaths project as a whole.

Teacher education in the Zambian context was analysed before discussing the theoretical framework, and a discussion on Number Sense concluded the chapter.

In the course of these discussions, a number of issues were raised with a focus on use of mobile phones as a visualisation tool in teaching Number Sense.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents an account and justification of the chosen research methodology used in this study. In this chapter, I briefly outline and discuss the procedures followed while conducting my research by considering aspects of orientation, methodology, participants, research design, techniques/tools, analysis, validity and ethics. A clear picture of my interest in the VITALmaths project should emerge by the end of this chapter.

3.2 RESEARCH ORIENTATION

Taylor, Sinha and Ghoshel (2011) define research methodology as a systematic investigation into a study of materials and sources in order to establish facts and reach conclusions. Terreblanche, Durrheim & Painter (2006) refer to methodology as the tools that are used to research reality and how the researcher goes about finding what he/she asserts to be true.

Approaches to methodology in research have been seen to reside in paradigms and communities of scholars (Cohen, Manion & Morrison, 2011, p.5). Kuln (1962) holds that "a paradigm is a way of looking at, or researching phenomena, a world view, a view of what counts as accepted or correct scientific knowledge or way of working, an accepted model or pattern" (p.5).

Researchers ought to know how participants understand and interpret situations (Pring, 2000). It is for this reason that researchers talk of the subjective meanings of those whom they are researching: the different understandings and interpretations that the participants bring with them to the situation (Pring, 2000). For my study, I explored the subjective understandings and interpretations that are the experiences of the participants concerning the use of VITALmaths video clips as a visualisation tool in the teaching of number sense. My research was therefore conducted within the interpretive paradigm.

According to Creswell (2013), a paradigm is a set of assumptions or beliefs about fundamental aspects of reality that give rise to a particular world view (p.47). He adds that a paradigm addresses fundamental assumptions taken on faith, such as beliefs about the nature of reality (ontology), the relationship between the knower and the known (epistemology) and assumptions about methodologies. This is echoed by Bertram & Christiansen (2015) who assert that a research paradigm represents a particular worldview that defines, for the

researchers who hold this view, what is acceptable to research and how this should be done (p. 22). They add that working within a particular paradigm determines choices that include the following:

- What kind of questions should be asked
- What can be observed and investigated
- How to collect data
- How to interpret the findings (p.22).

3.2.1 Interpretive Paradigm

Interpretivists aim to understand the social world. They recognise multiple interpretations as equally important. Newby (2010) observes, "interpretivism underpins the qualitative approach to research".

Selecting the research methodology involves decisions about the research paradigm, research approach and research method (Bertram & Christiansen, 2015). Research paradigms include the fundamental concepts and values about the nature of reality and the scientific pursuit of knowledge (Bertram & Christiansen, 2015).

3.2.2 Research Approaches

Since my study was conducted in the interpretive paradigm, one approach that suited this study was the qualitative one. Newby (2010, p.4) observes, "Interpretivism underpins the qualitative approach to research". Qualitative research is an inquiry process of understanding where a researcher develops a complex, holistic picture, analyses words, reports detailed views of informants and conducts the study in a natural setting (Creswell, 2007). As is the case in my study, in qualitative research, a researcher quite often approaches reality from a constructivist perspective, which allows for various meanings of individual experiences (Denzin & Lincoln, 2005). To explore and understand a fundamental phenomenon under investigation is a key concept or process in a qualitative research. Babbie & Mouton (2001) add that the primary goal of qualitative study is to understand and describe, rather than explain, human behaviour (p. 270).

In this study, I oriented the eleven student teachers to the concept of visualisation so that they could have an overview of the role of visualisation on the VITALmaths video clips on mobile phones. As the orientation of the teachers was from a perspective where I believe VITALmaths video clips have potential for success, my study took the form of a qualitative investigation that is underpinned in the interpretive paradigm. Drawing on the inferences

and judgment of the participants' joint meaning of information, I could infer whether the participants' engagement with the video clips enabled me to answer my research questions, stated in the next section.

3.3 RESEARCH QUESTIONS

The research questions that frame the study are:

3.3.1 Research Question 1

How can VITALmaths video clips on mobile phones be used by student teachers as a visualisation tool in the teaching of number sense?

3.3.2 Research Question 2

What enabling and constraining factors do student teachers encounter when using mobile phones to teach number sense?

3.4 RESEARCH METHODS

3.4.1 Case Study

Case study research designs focus on small groups, projects, institutions or companies. Basically, they are intensive investigations of factors that contribute to characteristics of the case under study (Bertram & Christiansen, 2015). Additionally, case studies draw on various sources of information, usually in chronological order, to articulate issues and ultimately create a rich textured description of a social process. As is the case in my study, case studies are more suited to researchers dealing with the why and how questions, and in phenomena where the researcher has little control of those embedded in real life contexts (Bertram & Christiansen, 2015).

Cohen, Manion & Morrison (2011) assert that case studies recognise and accept that there are various variables that operate in a single case, and therefore to catch the implications of these variables often requires more than one tool for data collection (p. 289). In this regard, I used triangulation in my data collection.

In this study, eleven student teachers at one of the Universities in Lusaka formed the case. The purpose of the study was to investigate how VITALmaths video clips on mobile phones could be used as visualisation tools by student teachers to teach number sense. The unit of analysis was therefore the eleven student teachers' experiences of how they used the visualisation video clips on mobile phones to teach number sense.

3.4.2 Sampling and participants

The research was conducted with eleven student teachers of a University in Lusaka, (there were initially twelve, but one opted out). The student teachers were key partners in this research, and as such were carefully selected. Cohen et al (2011) reiterate that purposive sampling is often but not exclusively a feature of qualitative research. They add that in this type of sampling, "the cases to be included in the sample are hand-picked by the researcher on the basis of their judgement of their typicality or possession of the particular characteristics being sought" (p. 156). My sampling was purposive because I carefully selected eleven research participants who were: (i) student teachers at the institution where I am based and were willing to take part in the project (ii) were in possession of a mobile phone on which VITALmaths video clips could be uploaded, and (iii) were undertaking a primary teacher education course.

The eleven student teachers were divided into three groups (two groups comprised four students each, and one group had three students, since one had opted out) and conducted their teaching practice in Grade 7 classes in four primary schools in Lusaka Province. Thirteen VITALmaths video clips, (www.vitalmaths.com), were uploaded on the mobile phone of each student teacher. Though the students teachers were given an opportunity to familiarise themselves with the content of all the topics uploaded on the phones, this study only considered three topics: Sum of Consecutive Odd Numbers, Rectangular Products, and Palindromic Sums. Generally, the video clip on each topic was designed in such a way that the same concept was explained in two or more methods, with at least one of the methods incorporating the aspect of visualisation. During implementation of the lessons by each of the eleven teachers in the four schools, each group was assigned a topic based on a specific video clip and the mobile phone was used as a conduit to present the video. In all these topics, the focus was on number sense. Some mobile phones were sourced for learners so that they could watch the VITALmaths video clips as the student teacher was presenting. As most of the classes had a high numbers of pupils, pupils were put in groups and asked to share one mobile phone for the duration of the lesson. Since one of my data collection techniques was observation, I observed and video recorded each of the eleven lessons. Observation as noted by Nieuwenhuis (2011), observation is an essential data gathering technique as it has the potential to provide the researcher with an insider perspective of group dynamics and behaviour in different settings (p. 84).

3.5 RESEARCH DESIGN

Data generation took place in six phases. This was necessary to enhance validity and reliability, and for triangulation through the inclusion of a variety of data collection techniques and methods. These included workshops with student teachers, orientation lessons, observations, individual interviews and focus group discussions with the participants.

The six phases of data generation are detailed below.

Phase 1: Training/Awareness

In the first phase, I taught the importance of visualisation in mathematics to my class of 50 student teachers. This was a new inclusion in the curriculum. I then conducted an awareness workshop with the same class on using mobile phones with VITALmaths video clips. Integral to the content of this workshop was the importance of how mobile phones could be used to harness visualisation opportunities in the teaching process of number sense.

Phase 2: Selection and planning Workshop

Phase 2 consisted of selecting eleven student teachers who participated in this study. Initially, I asked for four volunteers from the workshop in Phase 1. Since the response was overwhelming, I picked twelve student teachers and placed them into three groups, one for each of the three selected video clips in this study. The three selected VITALmaths video clips were uploaded on the mobile phones of each of the participating student teachers. The student teachers were then invited to participate in a planning workshop where we designed lessons that incorporated the video clips. A lesson was specifically planned for each of the participants to pilot with a Grade 7 class during his/her teaching practice.

Phase 3: Pilot and planning

This phase was done in three stages:

i. Each student teacher taught a pilot micro-lesson with a Grade 7 class which was video-taped for reflection and planning purposes. The aim of this lesson was to familiarise the learners with using a video clip on a mobile phone and to afford the student teachers the opportunity to use the mobile phone as a teaching tool.
ii. A reflection on the lesson with the participating students was done.
iii. Each student teacher then uploaded the selected VITALmaths video clips for the main part of the project onto the mobile phones of the learners.

After the piloting stage, each of the eleven student teachers then planned a lesson to be implemented in Phase 4.

Phase 4: Implementation of the lessons

In this phase, each of the student teachers taught their lesson to a class in their respective teaching practice schools on a topic on number sense incorporating the VITALmaths video clips uploaded on their phones as well as on the mobile phones of the learners. Mobile phones were sourced, to be used by the learners who did not possess one. Each of the lessons was video recorded.

Phase 5: Interviews

After the teaching intervention, one individual interview with each of the participating student teachers was conducted and . After the individual interviews, a focus group interview with all the participants was done and also audiotaped.

Phase 6: Analysis

Cohen, Manion & Morrison (2011) explain that "qualitative data analysis involves organising, accounting for and explaining the data, in short, making sense of data in terms of the participants' definitions of the situation, noting patterns, themes, categories and regularities" (p. 537). Primarily, the purpose of data analysis was to characterise the experiences each of the eleven student teachers had with specific reference to the lesson they taught with the aid of the video clip.

Data from the recorded sequences of lesson as well as the student teacher interviews and focus group discussions was used to establish specific themes with reference to the above topics.

In this phase, I analysed the data collected from the individual and focus group interviews. The emerging theme that was key in the analysis was the teachers' experiences of the role that mobile phones play as a visualisation tool when teaching number sense

3.6 TECHNIQUES/TOOLS

Bertram & Christiansen (2015) observes that data collection methods employed in case study research include questionnaires, in-depth interviews, document analysis, direct and participant observation and focus groups (p. 65). The data collection tools employed in my study research were in-depth interviews, focus group discussions and observations. Eiselen and Uys (2005) observe that before one starts formulating questions to include in a research instrument, it is very important to have a clear understanding of the research question and the intended goals. I therefore linked each question in the interview schedule and focus group discussion to the research question and research goals.

3.6.1 Interviews

The interviews were semi-structured (Arksey & Knight, 1999). I followed up my initial questions where necessary, with probing questions, by either rephrasing the original question to clarify meaning or posing further different questions, which were suggested by the answers to the initial questions.

Somekh (2007) contends that interviewing is a means of gaining insights into students' knowledge and understanding. Vavoula (2009) recommends the use of interviews by mobile learning researchers as an approach based solution. He adds that interviews would also be able to capture different perspectives on the use of mobile devices for learning.

In this study, interviews were used to gain feedback from students on the prospect of providing mobile learning as an additional delivery platform, the usefulness of the mobile learning activities and also problems that the students faced, as outlined in the two research questions of this study.

3.6.2 Observations

The interpretive paradigm is underpinned by observations and interpretations. Klein & Myers (2009) noted that to observe is to collect information about researched events, while to interpret is to make sense of the observed interpretations by drawing inferences or judging the link between the information and an abstract pattern. This blends well with my study in which I observed the eleven participants' engagement with the VITALmaths video clips. By judging and drawing inferences of the participants' lesson presentations, I could

interpret whether the participants' engagement with the video clips reinforced my answering of the research questions.

I video-recorded all eleven lessons the participants presented using the VITALmaths video clips. I also took field notes to enhance the information provided by the video. The field notes helped me capture information such as whispers and gestures that could not be picked up by the microphones (Plowman, 2004).

3.7 ANALYSIS

Cohen, Manion and Morrison (2011), note that data analysis implies making sense of data in terms of the participants' description of the situation, noting patterns, categories, regularities and themes. They add that this involves organising, explaining and accounting for data (p. 537). The analysis in this study was done in two parts; the vertical and the horizontal analysis. In the vertical analysis, a brief outline of each of the three video clips used in this study was given. This was followed by a brief description of the lesson presented by each of the eleven teachers. This was followed by a presentation of the way the video clip was used in the lesson. Finally, I presented the teachers' views based on the interviews I held with them.

In the second part, the horizontal analysis gave a summary of the analysis by considering all the eleven participants' views given in the focus group discussion. Similarities and differences in the participants' views were presented and discussed.

3.8 VALIDITY

Anderson (2003) postulates that the "most fundamental principle for ethical acceptability is that of informed consent: the involved participants must be informed of the nature and purpose of the research, its risks and benefits and must consent to participate without coercion" (p.18).

The ethical considerations reviewed for this study were based on the Rhodes University Faculty of Education Ethical Approval Application Form. On the Approval form, detailed information on the research, the nature of data collected and confidentiality issues, as well as the rights of participant(s) to withdraw from the study, were stipulated clearly

The principle of informed consent as espoused by Ruane (2005) is about the right of individuals to determine whether they want to participate in a research study. To enable the

participants to make these decisions, I thoroughly informed them about all aspects of the research project (Ruane, 2005). Subsequently, at the heart of informed consent were freedom of choice and self-determination (Ruane, 2005).

Furthermore, Ruane (2007) also advances the issue of voluntarism, as the participants were to volunteer to be part of the research. He observed that "institutional settings entail authority relationships that are inconsistent with true voluntarism" (p.19). There is a possibility of students volunteering for a study out of obligation because the researcher is seen as more powerful (Anderson, 2003). This implies that the students might have found it hard to be at variance with authority as I was a tutor on the course. I therefore emphasised to the participants that their participation in this study was by no means linked to achievement in the courses I was offering.

My request and consent letters were disseminated to all the different stakeholders, i.e. the Vice Chancellor of the institution where the student teachers are based (see appendices A, B and C) and the schools where the student teachers conducted the lessons.

By agreeing to be interviewed and video recorded the participants agreed for the results of the interview and video recording to be used for research. I also member-checked the data by availing the transcripts to the participants to confirm if what I had captured was a true reflection of their responses.

In a quest to enhance validity and reliability in this study, triangulation was used. Triangulation (Cohen et al, 2011; Bertram & Christiansen. 2015), is the use of two or more methods of data collection in the study of some aspect of human behaviour. Cohen et al (2011) further assert that the use of a multiple methods approach contrasts with the ubiquitous but generally vulnerable single method approach. I incorporated a variety of data collection techniques and methods that included orientation lessons, workshops with student teachers, observation, interviews and focus group discussions.

A pilot study was initially conducted to ensure validity of data. Before administering data collection instruments to participants in a study, it is advisable for the researcher to test on a small sample. It is cardinal to conduct a pilot study to identify areas that may need revision and correction, to refine both the instruments and data analysis procedures to better achieve the data analysis objectives, and to review the choice of statistical tools and computer programmes (Bertram & Christiansen. 2015).

Bertram & Christiansen. (2015) further notes that analysis of the pilot study reveals flaws in some questions and provides an opportunity to suggest possible improvements. In addition, a pilot study enables the researcher to:

- Make amendments necessary to maximise returns and minimise the error rate on answers
- Categorise the open-ended questions to a reasonable degree
- Perform the analysis on the pilot sample and test out all the computational procedures to produce some initial hypotheses
- Evaluate the adequacy of the data for the research questions (p.17).

3.9 ETHICS

3.9.1 Respect and dignity

I will communicate to the participants what the research is all about without withholding any information pertaining to their participation or that could influence their choice to take part in the project. I will also make it explicitly clear to them that they have the right to withdraw their participation at any time. Their anonymity will be guaranteed.

All the collected data will be kept confidential and will only be shared with my supervisor. In the final write-up of my thesis, pseudonyms will be used.

3.9.2 Transparency and honesty

I will ask for written consent from the Vice Chancellor of Chalimbana University and the four head teachers where the four participants will be doing their teaching practice for permission to allow them to take part in the project. I will also make it clear to the participants that their participation is voluntary.

I will carry out member-checking of the interview transcripts to ensure that what I recorded is a true reflection of the information given by the participants.

3.9.3 Accountability and responsibility

Since all the four participants are students at the institution where I am a tutor, I will ensure that power relations are reduced as much as possible by encouraging them to give their honest opinion without fear of any repercussions. I will assure them that their participation in this study will in no way have any compromised impact on their participation in my class.

3.9.4 Integrity and academic professionalism

Throughout my research, I will uphold the professional and academic standards and integrity demanded by Rhodes University, by adhering to the laid down rules and standards of the institution. My findings will be based on authentic data that I collected. My analysis will be based on my empirical work and not on my own assumptions and opinions.

3.10 CONCLUSION

The research paradigm that underpinned my research study and guided my design and process was discussed. I also explained how the six phases that I employed in my research design enabled me to answer my research questions. An explanation of the qualitative approach and the sampling process in my study was also presented. Finally, I discussed ethical and validity practices in an attempt to maintain the trust of my participants and ensure transparency.

By being candid about the processes involved in conducting this study, and explaining such, my research might contribute to educational research in general, and to the VITALmaths project in particular.

CHAPTER 4: ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

The data being analysed in this section was collected through interviews, a focus group discussion and lesson observations. The analysis consists of two parts; the vertical and the horizontal analysis. In the vertical analysis, I begin with a brief outline of each of the three videos used in this study. Thereafter, for each of the eleven teachers, I give a brief description of the lesson that was presented and the way the video clip was used in the lesson. Finally, I present the teachers' views based on the interviews I held with them.

In the second part, the horizontal analysis gives a summary of the analysis by considering all the eleven participants' views given in the focus group discussion. Similarities and differences in the participants' views are presented and discussed.

Codes that I have used to identify teachers are as follows: Teacher 1's views in the interview on line 4 is coded as IT1L4, (I for interview, T1 for Teacher 1and L4 for Line number 4), and Teacher 2's response on line 50 is coded as IT2L50. Similarly, participant 1's views in the Focus Group Discussion on line 7 is coded as FGD P1L7, and the transcription of participant 2 in the FGD on line 8 is coded as FGD P2L8.

4.2 A BRIEF OUTLINE OF EACH VIDEO CLIP USED

The lessons taught by the eleven student teachers were based on three VITALmaths video clips: Rectangular Products, Sum of Odd numbers and Palindromic Sums (www.vitalmaths.com). In addition to English, the VITALmaths video clips are available in German and isiXhosa.

4.2.1 Rectangular Products

This video aims at illustrating how the decomposition of two-digit numbers can be used to find the area of a rectangle. As shown in Figures 4.2.1a and 4.2.1b below, the area of the rectangle remains the same despite dividing it into four parts as a result of decomposing the numbers 38 and 26 that represent the length and width of the rectangle respectively.

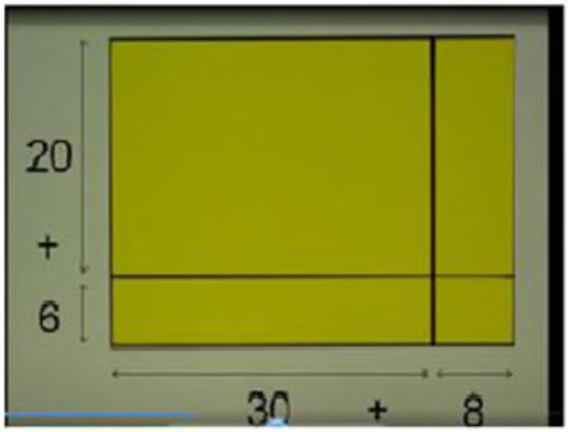


Figure 4.2.1a

Figure 4.2.1b

Figure 4.2.1: Screen shots of area of video clips

Source: www.vitalmaths.com

The video demonstrated that the sum of the area of the four parts of the rectangle formed as a result of decomposing the numbers 38 and 26 is the same as the product of 38 and 26 without decomposing or breaking down the numbers.

Decomposing numbers into place values, in this case into tens and ones, is one characteristic of Number Sense. This feature is key in developing children's number sense and their understanding of place value. Another concept that was illustrated in this video was that when a rectangle has been divided into smaller rectangles, the total area remains unchanged.

4.2.2 Sum of Consecutive Odd Numbers

This video demonstrated the concept that the sum of consecutive odd numbers, on condition that the first odd number is 1, is equal to the square of the number of consecutive odd numbers added. As demonstrated in Figure 4.2.2 below, the first line illustrates that in the addition of 1 and 3, there are two odd numbers involved and the result is the same as squaring 2. The same principle is applied to the rest of the numbers.

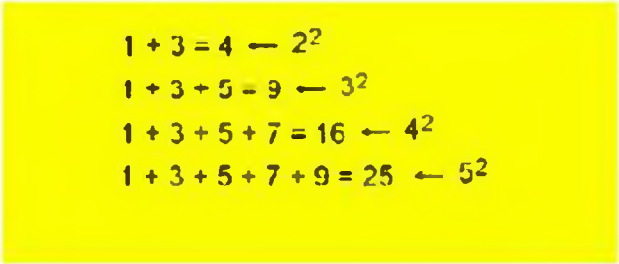


Figure 4.2.2: Screen shots of sums of consecutive odd numbers video clips
Source: www.vitalmaths.com

The visualising aspect of adding 1 and 3 to form a square is illustrated in Figures 4.2.3a and 4.2.3b below:

Figure 4.2.3a

Figure 4.2.3b

Figure 4.2.3: Screen shots of consecutive video clips

Source: www.vitalmaths,com

This video clip gives credence to the fact that the sum of a sequence of consecutive odd numbers is a square shape which can be presented both as a number and at the same time as a square shape corresponding to the number of squares equal to the sum, on condition that the first odd number in the sequence is 1.

4.2.3 Palindromic sums

The video as shown in Figure 4.2.4 below, illustrates that the palindromic sum of a set of numbers can be expressed as a square of the middle number. This is the number about which the palindromic set of numbers is symmetrical, and also the largest number in that set.

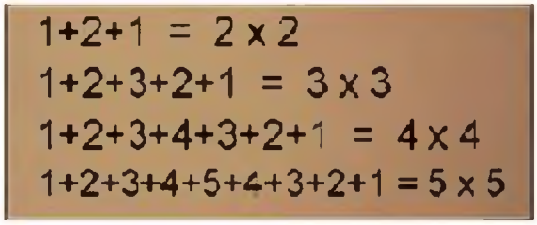
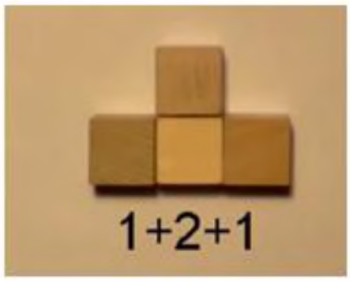


Figure 4.2.4: Screen shot of Palindromic sum of numbers video clips
Source: www.vitalmaths,com

The video further demonstrates that, since each sum is a square, the sum can also be expressed as a square polygon. For instance, the addition of 1 + 2 + 1 expressed as 2 x 2 is illustrated in Figures 4.2.5a and 4.2.5b below, as a square with side length of 2 units.



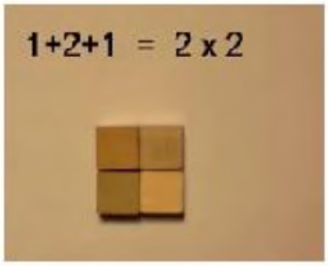


Figure 4.2.5a: Figure 4.2.5b

Figure 4.2.5 Screen shots of Palindromic sum video clips
Source: www.vitalmaths.com

The same principle applies to the other sets of numbers.

The illustrations from the three topics in the video clips underscore the principle that the concept of number can be illustrated in several ways. This is in line with what Bobis (1996) refers to as Number Sense - an organised conceptual framework of number information that enables a person to understand numbers and their relationships, and to solve with flexibility mathematical problems not bound by traditional algorithms.

4.3 PART A: VERTICAL ANALYSIS

4.3.1 Teacher 1

4.3.1.1 Brief Description of the lesson and how the Video Clip was used

Teacher 1, aged 21, taught the lesson on the sum of consecutive odd numbers. He introduced the lesson by asking the learners what they understood by an odd number. He then asked the class to give examples of the type of shapes that they knew and the properties associated with the shapes. Next, he asked them to give examples of odd numbers and gave examples of adding consecutive odd numbers starting from 1. He took them through the lesson without first exposing them to the videos. He asked them questions based on what he had taught and then arranged the learners in groups and screened the video clip. After allowing the learners to watch the video clip, he engaged the class in a discussion based on what they had observed from the video clip.

4.3.1.2 Interview

Teacher 1, a male student teacher, was the only one of the 10 participants who indicated that he was aware of visualisation prior to the launch of the project - the other participants indicated that they only learnt about visualisation during the Awareness/Workshop in Phase 1. He defined visualisation as imagining something abstract and described visualisation in Mathematics as the ability to solve mathematics mentally with no recourse to writing anything.

He indicated that from a mathematical perspective, number sense was the ability of being able to coordinate and work with numbers accurately.

He affirmed that the video clip contributed to visualisation in his teaching and remarked that:

IT1L44: *They really contributed in the teaching because the learners were able to look at what was being said, they were able to see what was being taught, unlike drawing on the board because most learners have a mentality where, when you draw something on the board, once that thing is rubbed off or erased, the whole concept is rubbed off in their mind, but with the help of video, they were able to see and maybe others had a chance to touch the phone, which was a greater thing to them, it will stick in their mind for a long period of time*.

Teacher 1, interacting with learners in Figure 4.3.1 below, pointed out that there was a need to use more phones with bigger screens so that learners could have a clear view of the videos, and that having the audio feature would greatly enhance the experience.

On the issue of whether teachers should be encouraged to use mobile phones in their teaching, he affirmed that he was for the idea, but was quick to point out that:

IT1L52: *Definitely yes, I think mobile phones would really help, I would still get back to the same aspect of saying that it all depends on the teacher, if the teacher is really a teacher not just someone who wants to get paid at the end of the month, who would like the learners to be someone in life, regardless of how many phones one has, regardless of how big the class can be, if the teacher is really wanting to help the learners, even in a Grade 7 class one can work with three or four phones, it all depends on how the teacher wants the class to be.*

Figure 4.3.1: Teacher 1 working with learners as they watch a video clip on a mobile phone
Source: Video Recording of lesson of Teacher 1

4.3.2 Teacher 2

4.3.2.1 Brief Description of the lesson and how the Video Clip was used

Teacher 2 is a male teacher aged 26. The lesson he taught was on Rectangular Products. He started the lesson by first letting the learners watch the video. His argument was that he wanted them to find out what concepts they would learn from the content of the video clip before receiving assistance as a way of promoting autonomous learning. Based on the learners' responses, he clarified where the learners faced challenges understanding the concepts. He then replayed the videos to help clarify areas where the learners faced challenges.

4.3.2.2 Interview

Teacher 2 observed that visualisation implied making a picture of something in the mind, through drawings or using videos. He added that visualising a number involved association of a number with some object. He noted that:

IT2L15: *To visualise a number, for instance, I can say the number three, I can get three ball pens and say these are three ball pens representing the number three, so I have made a picture of that number, yes.*

He elaborated that visualisation in mathematics is a situation where you deal with numbers to make a picture and something practical out of those numbers.

Teacher 2's understanding of number sense was the ability to use numbers in a variety of ways. He remarked that**:**

IT2L17: *Number Sense is the ability of using number in different ways, yes, for instance, if I say two plus two plus two is equal(s)to six, instead of adding that number by itself three times, it is the same as multiplying two by three which will still give us six.*

He maintained that numbers were important in real life because they helped people in many ways, including counting objects and in banking. He added that mathematics was all about numbers and without numbers, there could be no mathematics.

His view of presenting a lesson with the help of a video was that it was a good idea but was time consuming as compared to the conventional way of teaching. He added that there was also a need for a good device for information to be shown properly, and commented that:

IT2L27: *Presenting a lesson with the help of a video needs enough time and it also need a good device that will show information properly, so it is okay, though it is time consuming as compared to if you were not using a video.*

He reiterated that the aspect of visualisation enhanced the presentation of information on the video clips, claiming that:

IT2L29: *It enhanced the information because I started with a video in my case for them (learners) to be able to see what they could, thereafter I explained that which was in the video on the board so that if they missed out anything, they were going to get it from my explanation. And after my explanation, I again took them back to the video, saying can you go back to the video after I have explained, they go back to the video again so that they*

cement on all those areas that they did not understand when they were watching the video in the first place, so I think it was helpful because I explained first, after they watched and then I took them back to the video and I guess the time I took them back to the video the second time, they were able to understand the video.

He observed further that the videos were relevant to Grade 7 learners. Most of them were thirteen years old and capable of understanding a video, unlike in the lower grades of Grades 2 and 1. The advantage that videos have is that they are easy to use and are self-explanatory, so a teacher does not have to talk much; he just needs to clarify where need be. He was however quick to reiterate that the constraining factor was that using mobile phones in teaching was time consuming.

He explained further that after the pupils watched the videos, they were able to understand a concept and make a picture out of that. On whether teachers should be encouraged to use phones in their teaching, Teacher 2 had mixed feelings as expressed in his response:

IT2L51: *On that one, it needs some debate a little because this time around the way people are using phones like more especially pupils those who are doing primary and secondary, if we are to bring these (mobile phones), maybe it might promote pupils doing other things on their phones just after the lesson, which might disturb other lessons, yes because this was just specifically for mathematics, meaning that pupils will be allowed now to go with their phones to school, yes so you find out that may be one of the pupils has got some videos which are not okay for them and may be they might spoil others.*

4.3.3 Teacher 3

4.3.3.1 Brief Description of the lesson and how the Video Clip was used

Teacher 3 is female, aged 21. The topic she taught was based on the video clip, Palindromic Sums. She approached her lesson by giving the learners a sequence of numbers and asking them to find the next number in sequence. She then brought in the concept of Palindromic sums by giving them an example on $1 + 2 + 1 = 2 \times 2$ and then asked them how the idea could be extended to other numbers whose symmetrical number is greater than 2. After discussing their responses, she asked them to watch the video clip on Palindromic Sums. She then asked them to comment on anything they had noticed, that had not been apparent before watching the video. After the discussion, she stated, "*We add numbers in their sequence and get a square number this when you start with the first number and end with*

the first number in the sequence to get a square number", which I noticed the learners found hard to comprehend.

4.3.3.2 Interview

Teacher 3 explained that she understood visualisation as teaching and thinking in abstract, where you only use your head to think. She cited an example of visualisation as when one is adding eight to three, and said, "*Without calculating, without using anything, you just have to think and give the answer*".

According to her, Number Sense is the understanding of the relationship between numbers and of how they relate to one another. She added that numbers are important in life because they are what people use for calculating and could best be taught in a practical manner.

She argued that it was a bit difficult to present a lesson with the help of a video despite pupils seeing what was on the video, as they could not express themselves confidently in English to explain the Mathematical concepts they had observed in the lesson . However, when asked how the aspect of visualisation enhanced the presentation of information on the video clips, she responded that:

IT3L31: *It was very easy to...for the pupils to understand as for me, yes, but it is just that the pupils didn't respond according to the...but the pupils, but the problem with the video, I didn't see any problem with the video, because when I was asking them, they were saying they were seeing what was happening, the only problem I saw was the communication, they had problems with how to express themselves*.

She further commented that some of the material in the video clips was suitable for Grade 7 classes as it was easy and self-explanatory. She reiterated that the other disadvantage of the video clips was the lack of sound. She believed that had the videos been equipped with the audio feature, the issue of communication would have, to some extent, been lessened. The other challenges she cited were the small screen of the phone, which made it difficult for learners to view the videos clearly, and the inability of some phones to pause the videos.

On how the video clips contributed to visualisation in her teaching, she commented that the second part of the video, which starts with "Now let's visualise", enhanced the aspect of visualisation and she remarked that:

IT3L44: *Because those clips when they start playing, there is the first part, so when, like for the first part when it was one plus two plus one, the answer was what, was four, as the second one played, they at least had an idea of what is going to happen in the next level.*

Teacher 3 suggested that despite some challenges regarding teachers' use of mobile phones in their teaching, teachers should be encouraged to use mobile phones in their teaching.

4.3.4 Teacher 4

4.3.4.1 Brief Description of the lesson and how the Video Clip was used

Teacher 4 was female, aged 20. The lesson she taught was based on Sum of Consecutive Odd Numbers. Her approach to the lesson was asking learners what they observed when consecutive odd numbers starting from 1 were added. She gave them a couple of examples and asked what they observed about the answers obtained. They had challenges coming up with a generalisation about the answer. It was at this point that she asked them to watch the video, and then asked them if with the help of the video they could answer the question she had earlier posed. When it became evident that they had challenges communicating their views, she asked any learner who had grasped something to present to the class. Figure 4.3,2 shows one of the pupils presenting on the board his observation from the video clip.

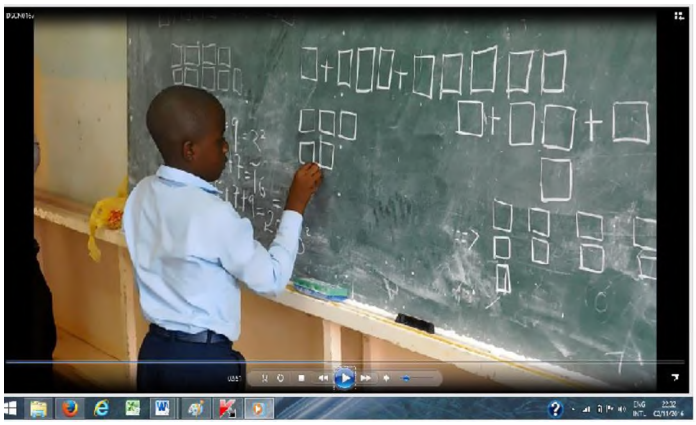


Figure 4.3.2: Learner demonstrating on the board

Source: Video Recording of Lesson of Teacher 4

The learner, though not getting the whole concept, demonstrated that he had grasped the basic concept from the video clip about the lesson. The video was replayed to help learners gain a thorough understanding.

4.3.4.2 Interview

Teacher 4 stated that visualisation was simply having a mental picture of something. She elaborated that thinking about a solution when you are asked a question is visualising, whereas visualisation in mathematics was the relationship between numbers and the formulas as well as the operations involved.

Her view on the importance of numbers in real life was that they helped people solve problems. She added that numbers are important in Mathematics because numbers are the language of Mathematics, and without numbers, there would be no Mathematics.

On her views about presenting a lesson with the help of a video, she asserted that:

IT4L32: *Now I think it helped to teach the lesson, it made the lesson easy because the children were thinking about the videos that they had watched, they were thinking about it, even though they could not explain what they really meant but they were curious to know, then when you start explaining they are eager to listen, because they want to find out what that video is all about, so it helped a lot.*

On the advantages of the videos, she felt that they were very useful in the lessons to both the learner and the teacher; as they could help with visualisation, and in the way one handled questions, and they were a good teaching aid. She reiterated that as most children did not have phones at Primary school and are not used to situations of a lesson being presented using a mobile phone, it was an advantage as it increased their curiosity. She observed that:

IT4L40: *Most children don't have phones, so when I use a phone to teach them they become more interested and they pay particular attention, so it is an advantage unlike bringing a diagram, they have already seen diagrams, so most of them will not pay attention, but once they see a phone, everyone would like to see what is in that phone, so they pay attention.*

Despite outlining the advantages, she said there were also some constraining factors. She cited the short duration of the video clips as one. The other disadvantage was the small screen of the phone, which she claimed was a challenge for most of the learners to view the videos clearly, considering that the phones were being shared.

She further pointed out that it was the first time for most of the learners to experience the use of a phone in the teaching and learning process in classroom, so some, instead of focussing on the lesson, had their focus more on the gadget.

On whether teachers should be encouraged to teach using mobile phones her response was:

IT4L58: *Yes, as I experienced today, it was easy for me to teach my lesson.*

4.3.5 Teacher 5

4.3.5.1 Brief Description of the lesson and how the Video Clip was Used

Teacher 5 is a male, aged 25 and the lesson he taught was on the Sum of Consecutive Odd Numbers. From the outset, Teacher 5 exposed the learners to the video clip. After the learners had watched the clip once, he asked them to list the major concepts (as shown in figure 4.3.3 below) they had learnt and asked them to explain what they understood about them. He engaged in a discussion with them to clarify concepts where there was a need. He exposed them to the video again for more clarity.

Figure 4.3.3: Learners taking down notes from Video Clip on Mobile Phone

Source: Video Recording of Lesson of Teacher 5

4.3.5.2 Interview

His understanding of visualisation was that it is a process of mental images whereby a learner would imagine, see or create a picture of something. He explained that visualisation in mathematics was the ability of a learner to flexibly understand concepts by using mental images. He elaborated that some numbers are too complex or abstract for learners to understand, so the ability of visualisation to create mental images can shed light.

He referred to Number Sense as the ability to understand numbers and the relationship between them. He added that the importance of numbers is that they are used for counting, calculating and budgeting. As for the importance of numbers in Mathematics, he alluded to the idea that they help learners understand what Mathematics is all about.

His view about presenting a lesson with the help of a video was:

IT5L27: *I think presenting a lesson with the use of videos, it helps a teacher in such a way that learners they don't just get the concept of number, which could be more complex for them, but if you use videos, since most learners are, as we know, they are very young people, so if we bring the concept of videos, it helps them because they easily understand with the use of images, they would easily create images from the videos.*

On how relevant the video clips were to Grade 7 learners, he articulated:

IT5L31: *I think I found the video clips important to Grade 7s in the way that it actually helped me in such a way that each and every learner concentrated, I used them (video clips) as visual aids, so each and every learner was able to see what was happening even me not being there as a teacher instructing each and every learner, they are able to see for themselves. I think it even helped those slow learners, because they were able to come up with an image of what the whole concept was all about, what the whole lesson I wanted to teach was all about, because after they watched the video clip, even the response from the learners, it was very good, okay let me just say it was good, not really that much good, but it was good from them, it was because if I was just to start teaching numbers just like that the odd numbers, I think I was going to have problems with them. So with the help of the videos, the videos just smoothened everything for me.*

He added that the video would also help the learners to understand and create more images and relate that to their everyday life experiences

The constraining factors, as he pointed out, were that some learners concentrated more on just staring at the visual aid, the phone, and not getting the main concept from the video. For others, the mathematical concepts were not easily grasped despite watching the video. The other disadvantage was that a teacher overlooked explaining certain key concepts taking it for granted that the videos had explained everything.

On the suitability of the videos for Grade seven7 learners, Teacher 5 observed:

IT5L45: *I think since this is a Grade 7 class we are talking about, what should be done is that, since these are videos we are talking about, in terms of the outcome of the videos..., the observation, the videos must be clear so that the learners are able to see, then the other thing is, since technology has brought a lot of things you don't have to get things that are complex. Since bringing the videos, as I alluded earlier, videos they help learners to make images, so the videos that are supposed to be downloaded are supposed to be in a way that, to a Grade 7 level, because there are some videos yes, on the same topic but some, they are*

more complex, so I think for this to be more effective get the right videos for a right class, I think that way it would work perfectly and the type of delivery or display of the video must be clear and they must be direct to the point. There must not be a lot of complexity in the videos.

Asked whether teachers should be encouraged to use mobile phones in their teaching, he reflected that inasmuch as it could be appropriate use mobile phones, there was a need to use them cautiously. He reflected:

IT5L47: *It is appropriate, okay, and again when it comes to the use of mobile phones, I think the use of mobile phones must come in where they are necessary, because it's not all topics whereby you could use mobile phones, some topics they don't need the use of mobile phones, there are some topics that it is a must that they will do you good when you use mobile phones. I think it is necessary yes, for teachers to use mobile phones but they must use them when it is appropriate.*

4.3.6 Teacher 6

4.3.6.1 Brief Description of the lesson and how the Video Clip was used

Teacher 6 is male, aged 26 and taught the topic, Palindromic Sums. He described visualisation as making images of real things, such as making pictures of something, about things that are being taught.

His approach was to explain the lesson to the learners and then let them watch the video clip. He then invited questions in areas where they had challenges and thereafter allowed them to watch the videos again, which as shown in Figure 4.3.4, they did with a lot of attention. He told the learners, "*I am going play the videos on the phones and you should make sense of the videos and connect them to what I have told you*".

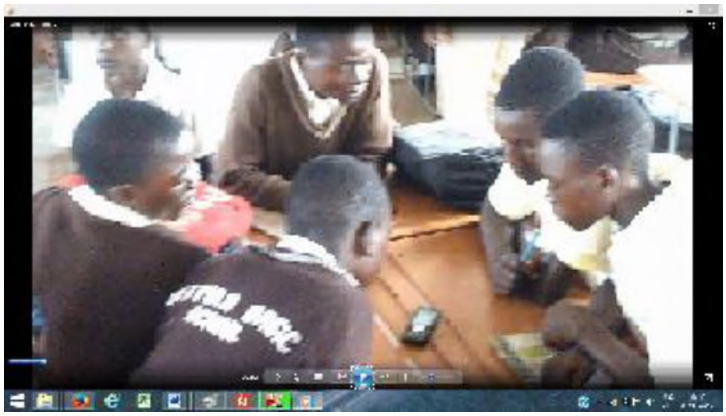


Figure 4.3.4: Learners watching a Video Clip on palindromic Sums

Source: Video Recording of Lesson of Teacher 6

4.3.6.2 Interview

He affirmed that numbers are important in Mathematics because they are used in everyday life. He added that numbers could be taught effectively in mathematics, if they are applied to real life situations.

His view about presenting a lesson with the help of a video was:

IT6L31: *I think it was excellent, because when I reached, when I introduced the topic, they were just all quiet, I just put the numbers and just say something but I didn't go into details, then when I gave them the phones, after watching the video clip, they became live, and they started answering and it was very easy for me to teach because it was very easy to get information from the learners , instead of me labouring explaining, explaining, I just had to get information from the learners and explain few things and it makes even the lesson to run very easy (easily).*

He was of the opinion that the video was relevant to Grade 7 learners as they were able to get certain information from the video clips even before he had begun to teach the lesson. This, he added, enabled learners to acquire some useful ideas, which they were able to relate to the lesson, which helped in enhancing understanding.

He acknowledged that one of the advantages of teaching with a mobile phone is that it promotes good participation from the learners. The other advantage was that it was easy for the teacher to teach because the video helped in the explanation and opened up the minds of the learners' right from the beginning.

He cited the disadvantage that some learners could not interpret the information from the video clips correctly. During the lesson presentation after watching the video, some learners expected a replica of what was in the video, other similar ideas based on the same principle as what was in the video were not easily understood. He postulated:

IT6L43: *The disadvantage, one, maybe it would make a teacher lazy, because this is the what, which is controlling the teacher in teaching. When you are making a lesson plan, when you reach there and you focus what is in here and your lesson would just be fixed according to the video which is there, the other thing which is the disadvantage is that you skip other things, like an example when I was supposed to, when I was given the same topic to teach, I jumped the definition of other, like Palindromic Sums, I jumped, I just went to the same video, what was there, as I was asking what is there and that and that, then I just give an explanation without giving the most important thing which is the definition and follow what is supposed to be done. Then to the learners, the disadvantage is that the learners will just be limited to the thing they have seen and when you try to bring the aspect of what they have seen, relate other things, it can be very difficult, so they will just be thinking what they have seen and want to learn what they have just seen, so that can be the disadvantage of using a phone.*

On whether teachers should be encouraged to use mobile phones in their teaching, he responded in the affirmative but clarified that it depended on the grade, as it would not be logical to use mobile phones in a Grade 1 class. Probed further which grade(s) would be ideal, he said it would be appropriate in the upper grades.

IT6L55: *I think starting from the upper level, say Grade 5, at that level, I would say yes, it can be good using a phone for teachers because it can help and if you need full participation from the children or from the learners, when you give them the phones, they can be able to understand easily, and they are able to cooperate with the teacher, and it can make the lesson easy as you are teaching.*

4.3.7 Teacher 7

4.3.7.1 Brief Description of the lesson and how the Video Clip was used

Teacher 7 is male, and aged 21. He taught the lesson on Palindromic Sums.

His emphasis was that the lesson on Palindromic Numbers was all about helping learners to understand a number of mathematical concepts. One of these was addition, and he wanted learners to understand that when objects are put together, they increase in number or size.

He also discussed the concept of multiplication. He emphasised that the clip agreed with the definition for multiplication as repeated addition since, according to him, when smaller sums were added together, they gave the same result as multiplying large numbers. He then allowed learners to watch the videos and asked them to comment on what they had observed. He summed up his lesson stating that Palindromic numbers, as observed from the videos, served as a simpler way of multiplying larger numbers in that when smaller products were added the sum was equal to the product of the whole.

4.3.7.2 Interview

Teacher 7 understood visualisation as having a mental picture.

His view of Number Sense was that it was the ability to relate to numbers, and expounded that numbers were important in Mathematics because they helped people solve Mathematics problems. To teach number sense, he added, there was a need to use concrete objects.

His view of teaching a lesson with the help of a video was that it could help learners form mental pictures. In his view, though the video clips were relevant to the lesson, he felt that they took rather too long to provide meaning to the lesson.

He however pointed out that the video clips had the advantage of helping learners solve complicated problems by breaking them into manageable sizes, though, he added, it required one to thoroughly understand the videos first.

He singled out the small font size of the text and the small screen of phones as disadvantages. He also alluded to the fact that some learners had more interest in the hardware (i.e. the mobile phone) than the mathematical concepts being discussed in the video as he remarked:

IT7L44: *The nature is like they only get interested in learning using a phone which they have not done before, but not really getting what the video is about.*

On the strategy to be used by the teacher when teaching using mobile phones, he suggested that prior to exposing them to the video clips, the lesson in the video should be explained to the learners. Then after watching the video, he added, they could be able to form images of the mental pictures that were in the video.

He was of the view that before encouraging teachers to teach using mobile phone, the phones needed to be worked on:

IT7L54: *Before they are worked on they shouldn't be using them.* Asked what needed to be worked on he noted:

IT7L56: *Before the font has been increased and the arrangement of breaking down of pictures into smaller ones so that they can generate ideas, it will make it difficult for learners to learn.*

He added that after the phones had been worked on as he suggested, only then could teachers be encouraged to use mobile phones in their teaching.

4.3.8 Teacher 8

4.3.8.1 Brief Description of the lesson and how the Video Clip was used

Teacher 8 is male, aged 22, and he taught the topic Palindromic Sums.

He approached the lesson by mainly focussing on helping learners to use addition skills and knowledge of properties to find sums that resulted in palindromic sums. After asking learners to watch the video he went round the groups asking them to report what they had observed. After discussing the video with the learners, he concluded that the use of square boxes to represent numbers could assist the learners to calculate or rather add numbers and see what type of palindromic charts or shapes they had produced with less difficulties.

4.3.8.2 Interview

His view of visualisation was imagining something. He understood visualisation in Mathematics as:

IT8L13: *Visualisation in Mathematics, I understand as being given a question and then now you try to come up with a solution, like you have been given in written form and then you now try to create things or images in your mind how you can come out with solutions.*

He described Number Sense as something to do with numbers, the calculation of numbers and how they related to each other. He asserted that numbers were important in Mathematics because they helped people with their mental abilities and in thinking more realistically.

On how the aspect of visualisation enhanced the presentation of information on the video clips, he noted that since it is a teaching aid it helped the learners well as they were able to follow systematically. He added that even before he could explain something to them, they were able to pick up some important points after watching the video.

On the advantages of teaching with a phone, he claimed that it was an effective teaching aid, but cited the small screen size as a constraining factor as the videos could not be viewed clearly.

As regards the strategies that were important and appropriate to consider when teaching using video clips on mobile phones, Teacher 8 remarked:

IT8L41*: Okay, when teaching using the mobile phones, when teaching you are supposed like, maybe they watched the first part, then you pause, then explain a bit, again you proceed with the video, they watch again and then you pause, you explain, so it is more like they watch and then you explain, you pause and then again you, ya, you explain bit by bit or step by step.*

He recognised that since there were some Grade 7s who could not read confidently, had the videos been equipped with sound, the learners would have been able to follow the lesson by simply listening to what was being explained.

He felt that teachers should be encouraged to use mobile phones because from what he had experienced personally they were a good aid, especially in Mathematics.

4.3.9 Teacher 9

4.3.9.1 4 Brief Description of the lesson and how the Video Clip was used

Teacher 9 is a male aged 20 and taught the lesson on Rectangular Products. He approached the lesson by repetitively playing the video and later emphasised, "*I think it's quite important to play the videos over maybe twice or three times so that the pupils they get the understanding from the videos, then as you present the lesson on the chalkboard, it is going to be clear enough for the students to understand sir.*"

In his lesson, his focus was on how Rectangular Products could help learners find the area of any given rectangle without many challenges. In his lesson presentation, shown in Figure 4.3.5, he focussed on demonstrating how to decompose bigger numbers into smaller numbers in order to find their products.

Figure 4.3.5: Teacher 9 presenting a lesson on Rectangular Products

Source: Screen shot from video of lesson of teacher 9

4.3.9.2 Interview

Teacher 9's response to the meaning of visualisation was that it was a mental picture of something.

He stated that when visualising numbers, he thought of many numbers, taking as an example the number 10. He was asked what comes to his mind when he visualised 10. He revealed that he thought about the different ways in which the number 10 could be expressed. This included it being divisible by 2, and being a product of 5 and 2. He described visualisation in Mathematics as trying to make a mental picture of how a Mathematics problem could be worked on.

He described Number Sense as numbers that of which one could make sense. He reiterated that numbers were important in real life because they are applied to almost everything that we do, for example business and record keeping. As for the importance of numbers in Mathematics, he stated that they were important because they are used in calculations and he added that number sense should be taught in a manner that would promote critical thinking.

On his view about presenting a lesson with the help of a video, he remarked that it was quite helpful as teaching with the help of a video and the phone is not something that learners often experience, so it attracted learners' attention. The learners were also curious to find out what was coming next on the video thereby heightening their concentration and participation.

Responding to how the aspect of visualisation enhanced the presentation of information on the video clips, he acknowledged that:

IT9L39: *Aah, I think they helped a lot, in a sense that you would watch the video clips, then you would think as in try to get the concept of the video whereby you try to relate to something, for instance, something that you already know in terms of Mathematics, then you try to relate to that, then you try to make a connection whereby more like a bond, whereby you can connect two modes of information, the information that is coming from the video clips and the information that for instance that you already know sir. The videos gave pupils the idea that they are not restricted to using one particular method in Mathematics but rather to interact and manipulate numbers e.g. breaking down numbers and finding the products separately and then adding them together, same applies to breaking down the rectangle.*

On how relevant the video clips were to the Grade 7 learners, his reaction was that in Grade 7, there are learners that had already developed curious minds and would after watching the video try to connect the information presented in the video to that presented on the chalkboard, so the videos were relevant.

On the challenges, he noted that slow learners generally had a challenge to grasp concepts from the videos in good time. The other challenges he brought out were the small screen size of the phone, graphics in the videos not being very clear and the large number of pupils in class against a limited number of mobile phones.

He supported the idea that teachers should be encouraged to teach using mobile phones because from what he had experienced, his view was that it was a good teaching aid.

4.3.10 Teacher 10

4.3.10.1 Brief Description of the lesson and how the Video Clip was used

Teacher 10 is female, aged 20, and she taught the topic on Rectangular Products (see Figure 4.3.6) below. She introduced her lesson by first explaining what the topic was all about, and gave them an idea of what they are supposed to do, emphasising that they needed to pay keen attention, then distributed the mobile phones.

Figure 4.3.6: Learners watching a video clip on Rectangular Products

Source: Video recording of lesson of teacher 10

She explained that the lesson on Rectangular Products was on finding the area of a rectangle. She indicated that there are various ways one can come up with an answer. She emphasised that as shown in the video clip, 26 x 38 = 988, the same result could be obtained by finding the area of a rectangle when it is cut into four rectangles.

4.3.10.2 Interview

Visualising, according to teacher 10, is just imagining something and trying to work on it. She contended that numbers are important in Mathematics because Mathematics deals mostly with numbers. She maintained that solving problems based on Mathematics, "*minus you solving it with your hand*", but by simply looking at it on the board she maintained, is what is meant by visualisation. On her view about presenting a lesson with the help of a video, she remarked that it was effective, because just after watching the video, they were giving out answers based on what they saw in the video clip. "*Like they say, China's rule which talks of I see I forget, I see I remember something like that*", so once you see you will be able to remember.

Responding to how the aspect of visualisation enhanced the presentation of information on the video clips, she said:

IT10L41: *That part when like the topic that we were presenting, it was based on finding the area of the rectangle using the visualisation video clip, where they were cutting the rectangle and later adding it, so it simply shows that in Mathematics, the formulas that we use, they are not limited, we can use anything to come up with the same thing.*

She also emphasised that the participation was good because after watching the video when she asked a question, most of them had something to say, based on what they saw.

She identified the small size of the screen of the phone as a disadvantage, and highlighted learners' attention as an advantage. The other disadvantage, she added, was that some pupils if just left on their own for some minutes, would remove the VITALmaths video clip and start searching for other things on the phone.

On what should be done to make VITALmaths more effective in promoting conceptual understanding of a lesson in a Grade 7 class, she felt that it would be better to just have an application on the mobile phone that only contained the VITALmaths information to avoid instances where learners would be tempted to search for other things on the phone.

Asked if teachers should be encouraged to use mobile phones in their teaching, she stated:

IT10L67: *They should be encouraged because it helps both teacher and learner, one, the teacher won't be that involved, the teacher will just give more less like an introduction, then the duty of the learner will be just to observe, then the teacher will also try to explain where the learners didn't understand, but mostly when you look at the VITALmaths, it's clearly explained, so it will work for both learner and teacher.*

She however, emphasised that to avoid temptations by learners to search for other things on the phone, some which may be destructive, a gadget such as a projector, would be ideal. Her argument was that unlike a mobile phone, on a projector, learners' attention will just be focussed on one thing.

4.3.11 Teacher 11

4.3.11.1 Brief Description of the lesson and how the Video Clip was used

Teacher 11 is male, aged 22 and taught the topic Sum of Consecutive Odd Numbers. He introduced the lesson by first explaining some concepts on the chalkboard. He then distributed the phones and asked learners to discuss what they had observed in the clip that was of relevance to sums of odd numbers. After a brief discussion, he asked a member from each group to present what they had observed in the video clip.

4.3.11.2 Interview

He revealed that at the same time as the project started, he undertook some research on visualisation, and discovered that it dealt with thinking of the situation such as making a picture of something.

Number sense, according to him, implied being conversant with, and understanding how to operate numbers. He added that numbers were important in real life because they are used for counting and in calculations. As for the importance of number in Mathematics, he explained that Mathematics was about dealing with numbers in order to carry out calculations, hence the importance of numbers, it is not a subject where you write notes only.

He added that an effective way of teaching number sense was through use of concrete objects.

On his views about presenting a lesson with the help of a video, he affirmed that it was good as the learners would be able to observe what was happening and visualise as you explain.

He observed that visualisation enhanced the presentation of information on the video clips, in that:

IT11L31: *Okay, when first of all, we had numbers, we were adding odd numbers and then the aspect of visualisation came in when those boxes were displayed and they were making perfect squares, that's when the aspect of visualisation came in.*

He elucidated that he found the video clips relevant to Grade 7 learners because they were able to visualise the things he was explaining, and they were able to see, for example, how the addition of two or more consecutive odd numbers would give a perfect square. They were also able, he continued, to see how the issue of the perfect squares, the boxes, also played a part, and visualise using those same boxes.

Considering the Grade 7 lesson he presented, the part that he found useful was the one where the perfect squares were being made after adding. On the other hand what he felt was disadvantageous was that presenting a lesson using video clips on mobile phones being new to the learners, it took a while for them to connect what the teacher was presenting on the chalkboard with what was in the video. The other constraining factor was the inadequate number of phones. He added that, while the learners were viewing the videos, one learner

asked if they could be given more phones. This, compounded by the small screen of the phones, gave learners, who had been put into groups, not very clear view of the videos.

On the learners' participation in the lesson, he said the participation was good and remarked:

IT11L45: *Okay first, after I had explained to them, okay I think they had, because for me I had played the videos maybe twice, so it was in them they had understood what was happening, so I think that is why they were participating, they saw what was happening.*

Regarding what could be done to make VITALmaths video clips on mobile phones more effective in promoting conceptual understanding of a lesson in a Grade 7 class, he observed:

IT11L51: *Okay, here as I said earlier, there was someone who was saying we need more phones, which means they can't, they are unable to see clearly what was there, so if phones with maybe larger screens can be used that one will be, because the font size, especially the letters, is not clear, they are just too small. So if maybe we use phones which have got writings or numbers that are clear then that will be okay.*

He finally indicated that teachers should not be encouraged to use mobile phones in their teaching because it would distract learners. He attributed this to the fact that during his lesson presentation, some learners had stopped watching the Mathematics video clip and started searching for other things.

4.4 PART B: HORIZONTAL ANALYSIS

In this part, I present a summary of the analysis by considering the emerging themes of the similarities and differences from the perspective of the eleven participants. The summary aligns with the two research questions of this study:

- How can VITALmaths video clips on mobile phones be used by student teachers as a visualisation tool in the teaching of number sense?
- What enabling and constraining factors do student teachers encounter when using mobile phones to teach number sense?

4.4.1 Use of VITALmaths video clips by Student Teachers

The student teachers' use of the video clips in the classrooms for teaching was generally approached from two perspectives. More than half of the teachers adopted a method where they first taught the learners using the conventional "chalk and talk" method. The teacher then asked learners questions based on what they had been taught. Thereafter, the teacher

allowed the learners to watch the videos and asked them to list the key features that they had observed in the lesson. The learners were then asked to explain the concepts based on the points they had listed as they watched the videos. The view of the teachers who adopted this approach was that the video clips would enhance the understanding of concepts in areas learners had not understood when the lessons were presented prior to exposing the learners to the video clips. This aligns well with the observation by Rogers and Price (2004) as noted in chapter 2, page (32) that in digitally enriched settings, students using mobile devices could explore, capture and manipulate both physical and virtual objects for active understanding. In some cases, a learner from each group was called to demonstrate to the rest of the class what they had learnt from the video clips. The teacher then consolidated the lesson by often referring to the videos and gave the learners an exercise with emphasis on replaying the videos in cases where they encountered challenges.

For the other group, the student teachers presented their lessons in more or less the same manner, with the exception that, right from the outset, the teacher allowed the learners to watch the videos first and then engaged the learners in a discussion later. The other steps of the lesson proceeded in a similar manner as the first group of teachers' lesson presentations.

It was noted that in both approaches to the lesson presentation, the teachers had to replay the videos with a view to enhance the learners' understanding. The teachers' strategy to replay the videos during the lessons aligns with the observation by Allyn & Bacon (2002) who assert that video recordings are asynchronous, therefore they are an ideal choice for schools as they can be paused or played back for clarity, making it convenient for the students to use them "anytime, anywhere". This has the potential to encourage autonomous learning in the learners. This finding was further acknowledged by So & Kim, (2008) in the literature, page (18) where they contended that with the ubiquity of mobile technologies, students are capable of learning seamlessly, in and out of the classroom, and after school time.

The differences in approach by teachers in the use of the videos clips as revealed in the lesson observations reaffirmed the VITALmaths project emphasis on teachers and learners using the video clips as autonomously and independently as they wished (Linneweber-Lammerskitten., & Schafer, 2010). This was also acknowledged by Jarvela, Naykki, Laru, & Luokkanen (2007) who emphasised that mobile devices could enable instruction to adapt to diverse and individual learners and possessed important opportunities to support differentiated, autonomous, and individualised learning.

It was however interesting to note that contrary to stating two different strategies in their use of video clips in their teaching during the interview, the teachers held a common view when asked the same question in the focus group discussion. They were all in agreement that *the ideal situation would be to let the learners watch the videos right at the beginning of the lesson, pause and invite questions and discussion based on the learners' questions and response (*FGD P1L100)

The findings further revealed that teachers' initiative in the use of VITALmaths video clips was a key factor. While the respondents concurred with what revealed in chapter 2, page (15), that technology had the potential to enhance the teaching and learning process, they however indicated that it largely depended on how well the technology was integrated into the whole process; otherwise, using technology just for its own sake could be detrimental. This resonates with Shuler (2014) who argued that " …this however does not imply that any new technology can be outrightly embraced in the teaching and learning process without thorough analysis of the nature of the technology and an investigation of the best methods suited for the implementation in a particular context" (p. 82). This view is further acknowledged by JISC (2004) who emphasise that learning using ICT should focus towards encompassing the learning potential and not just the use of ICT for its own sake.

4.4.2 Enabling factors and Constraining Factors

4.4.2.1 Enabling factors

The findings revealed that the respondents were of the opinion that visualisation, generally, had a lot of positive or enabling factors in the teaching of Mathematics in general and in the teaching of Number Sense in particular. They cited creation of mental pictures and diagrams as useful key visualisation aspects in problem solving. This aligns with what was revealed in the literature in chapter 2, page (9), though the literature elaborated more fully. The literature elaborated by adding that visualisation includes development of ideas and strategies of effective problem solving, and encouraging transmission of results and understanding, an indication that visualisation is not only confined to pictures and diagrams, (Arcavi, 2003; Bishop, 1989; Eisenberg & Dreyfus, 1986; English, 1997; Kadunz & Straesser, 2004; Presmeg, 1992; Stylianou & Silver, 2004).

Another enabling factor singled out was that by watching the videos, the learners were able to get some valuable ideas on the topic, which proved very useful when the concepts were later discussed in the lesson. Nine of the eleven participants (82 percent) alluded to the fact that the video clips were easy to use and were self-explanatory. They further explained that

this feature was made possible by the design of the videos as most of the concepts in the videos are self-explanatory thereby relegating the teacher's role to mainly that of facilitation. The teachers pointed out that....*mostly when you look at the VITALmaths, it's clearly explained, so it will work for both learner* and *teacher* (FGD P2L3). This view is acknowledged by Goos (2010) in chapter 2, page (35) who affirm that in this type of learning culture, teachers act as a facilitator and learning partner rather than the sole expert of knowledge.

The findings indicated that videos suited the ability of a Grade 7 class. They attributed this to the way video clips were designed. The videos were visually appealing and animating, and for Grade 7 learners who are essentially young people, these were important factors to engage them in the lesson.

The participants emphasised that, based on their experience of interacting with the VITALmaths video clips during their lesson presentations, visualisation was a useful tool for teaching and learning Mathematics. Their claim is supported by Kadunz & Straesser (2004) who argue that visualisation is a powerful tool for learners to construct mental and physical representations that correctly mirror mathematical relationships and concepts. The Zambia. M.O.E., (2014) also recognises the importance of visualisation by stating in the Zambian curriculum, that visualisation is a vital skill that is indispensable in the learning and application of mathematics and is also an important cognitive tool in problem solving (p.51).

Another enabling factor was that more than half of the respondents exhibited knowledge of number sense. This was cardinal because Number Sense is the mathematical domain that is at the heart of this study. Their view of Number Sense was that it is the relationship between numbers and how they relate to one another. This response was to a large extent in reference to the way the content on VITALmaths video clips is designed - to animate, and to develop different Mathematical concepts and processes (www.vitalmaths.com). The respondents' view of number sense aligns well with one of its characteristics, which is the ability to reason, think flexibly and understand relationships, which is a fundamental aspect required from simple arithmetic right through to complex mathematics (Gersten and Chard, 1999).

Use of the mobile phones, as noted by the teachers, increased learners' participation. The degree of attention was good in that the learners were curious to see what would come next on the video clip. *As they were watching the videos, their curiosity increased in anticipation*

of what would come next on the video clip (FGD P27). This view is echoed by JISC (2005a) who hold that in higher education institutions, using a mobile phone as a conduit to provide learning activities, has the potential to engage the students (p. 26).

Contrary to what ten of the respondents classified as a constraining factor of the phone not having the sound feature, one respondent pointed out that she was of the view that it was an enabling factor. She argued that the non-availability of sound in the video clips enhanced the visualisation aspect and encouraged both the learners and the teacher to interpret the content, thereby enhancing critical thinking. Anecdotal evidence confirmed this finding by stating that the sound was deliberately not embedded in the video clips.

As noted by six of the participants (55 percent), the mobile phones have the ability to replay the videos as many times as desired. Replaying the videos helped learners to get clarification on areas where they were not clear. The teachers emphasised that they would use the video clips as a visualisation tool to solve challenging problems by breaking them into manageable parts.

4.4.2.2 Constraining Factors

All eleven participants (100 percent) cited the small screen of the phone as a constraint. They noted that the small screen made it difficult for the learners to view the videos clearly. Ten out of the 11 participants (91 percent) pointed out that the lack of sound was a constraining factor considering that some of the learners could not read English confidently. This finding is supported in the literature, in chapter 2 page (17), Cooney (2008) accentuated that mobile technology that is not well designed can adversely affect usability and can have the potential to distract learners from learning goals. These include the small screen size, regulated text entry and limited battery life.

Ten out of the eleven teachers (91 percent) cited the inadequate number of phones as a constraining factor. The small number of phones meant that learners were put in groups and had to compete to have a clear view.

The other constraining factor cited in the use of mobile phones in teaching was that it was time consuming. This was attributed to the fact that it required a lot of preparation, unlike the conventional way of teaching.

Three of the participants (27 percent) indicated that use of a mobile phone in teaching was a distractor. This was attributed to the fact that some learners when left on their own during the lesson would stop watching the video clip on mathematics and start searching for other things. This claim resonates with the findings in a study conducted by Cooney (2008)

where it was discovered that most teachers viewed mobile phones as a distraction that had no place in school. Indeed, the benefits of ICT notwithstanding, there is a need to be mindful of the disposition of ICT for learning.

The short duration of the video clips (1- 3 minutes) was cited by 8 of the 11 participants (73 percent) as a disadvantage. It was felt that the duration was too short to make the concepts very clear to the learners.

The other constraint brought out by the student teachers was that some learners focussed more on the technology (i.e. the mobile phone) than the mathematical concepts in the video. This finding aligns with the growing global consensus in literature on research, on the impact of technology in education. There is emphasis that the focus should not be on teaching the technology itself but rather on affordances of the technology in education (Clark, 1994).

Failure by students to express themselves confidently on what they had observed in the video was yet another factor. This, according to the findings, was attributed more to the challenge to express themselves fluently that learners who use English as a second language generally have, than as a direct consequence of the project. The other constraint from the findings was the inadequate number of mobile phones in comparison to the number of pupils in class. This stems from a background that on average there is a high teacher-pupil ratio in Zambian government primary schools.

4.5 CONCLUSION

This chapter outlined the findings and discussion of the data. This was done with reference to the research questions of this study and by considering the similarities in the views of the participants. Concisely, the respondents acknowledged that the video clips on mobile phones were useful in the sense that they were straightforward and self-explanatory. Furthermore, pupils would access information by playing back the videos as many times as necessary to get clarity on the parts that were not clear, implying that even in the absence of a teacher, teaching would still go on. Additionally the level of concentration was high as the learners found learning using a phone to be novel, and they were eager to observe what would come next on the video.

On the other hand, it was felt that it was time consuming to effectively incorporate video clips on mobile phones into the lesson. Other disadvantages were that the video clips had no audio aspect, were too short and the screen size of the phone was too small. The final disadvantage was the small number of phones compared to the number of learners in class,

resulting in a number of pupils in a group sharing one phone. The mobile phone, it was observed, could be a distractor as there was a tendency by some learners to search for other materials not related to the lesson.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter concludes my research project in which I present the following: a summary of the findings, the significance of the study, recommendations, limitations of the study and suggestions for further research. Finally, I present my personal reflections on the entire study.

5.2 SUMMARY OF FINDINGS

During the data analysis process, a number of themes inevitably emerged. These are summarised here with reference to the two research questions that guided this study.

Research Question 1

How can VITALmaths video clips on mobile phones be used by student teachers as a visualisation tool in the teaching of number sense?

- The videos were sometimes used in a "chalk and talk" context. This is where the teacher would be referring to the video and at the same time writing and explaining some mathematics points on the board.
- The videos were sometimes used at the beginning of the lesson as a means to introduce a topic or an idea.
- The videos were sometimes used at the end of the lesson to consolidate what had been taught.
- The videos were also used to enhance the conceptual understanding of Number Sense.
- The teachers used the videos as a means for the pupils to share their learning on Number Sense.
- The student teachers at times used the videos as prompts for class discussion.
- The student teachers would often play the video clips repeatedly to reinforce an idea.

Research Question 2

What enabling and constraining factors do student teachers encounter when using mobile phones to teach number sense?

The enabling factors that the student teachers identified included the following:

- Creation of mental pictures and diagrams as key visualisation aspects in problem solving.
- Learners obtained valuable ideas on a topic before it was taught in class.
- Video clips were easy to use and self-explanatory.
- Some of the videos suited the ability of the Grade 7 learners.
- The videos were visually appealing and animating.
- The videos exposed learners to a variety of methods of solving the same question.
- The videos increased learners' participation, attention and curiosity.
- The videos motivated learners to explore.

The constraining factors that were identified by the student teachers included:

- Small screen size of the phone.
- Small font in the texts of the video.
- Short duration of the video clip.
- Regulated text entry.
- Inadequate number of phones.
- Inability of some phones to pause.
- Time consuming.
- Distracted learning when the learners where side tracked by the technology

5.3 SIGNIFICANCE OF THE STUDY

Just as Hyde (2011) and Haywood (2016) attest to the fact that mobile technology in the teaching and learning process is new in the South African context, so does this apply to the Zambian context. Despite the pervasiveness of mobile phone technology among students and teachers, little has been done to undertake research on the subject of exploring how mobile technology could effectively be incorporated into the Zambian education context. This study therefore investigated how VITALmaths video clips on mobile phones could be

used by student teachers as a visualisation tool in the teaching of Number Sense in Zambia. The study also analysed the enabling and constraining factors that student teachers encountered when using mobile phones to teach number sense. Despite the study identifying some challenges, it revealed that the mobile phone has the potential to be used as a visualisation tool in the teaching of Mathematics in general and Number Sense is particular. It is my hope that this study will not only contribute to the existing literature on mobile technology, but will also provide a platform for stakeholders to discuss and find solutions to how a mobile phone, from a visualisation perspective, can be utilized in the Zambian classroom.

5.4 RECOMMENDATIONS

Based on the findings of this study, I recommend the following:

- Teachers should be encouraged to produce similar videos that promote visualisation on various Mathematics topics at various levels based on the school syllabi.
- Conduct awareness and sensitization to demystify the wholesome negativity associated with use of mobile phones in Zambian schools.
- The mobile phone should be utilised as a teaching and learning tool in the classroom.
- Video clips that promote autonomous learning should be incorporated into teacher education programmes.
- Teachers and learners should use video clips autonomously and independently.
- Learners should be given adequate time to explore the videos.
- Adequate number of mobile phones should be sourced to be used in the teaching and learning process.
- The mobile phone used should have bigger screens, bigger fonts and graphics, and long battery life.

5.5 LIMITATIONS

My study was a qualitative case study conducted on a small scale as it was only confined to four research sites and eleven participants. Despite a wide range of video clips available on the VITALmaths database, due to time constraints, I only used three video clips in the study, and a total of eleven lessons were presented by the participants. Due to these factors, the findings cannot be generalised to a wider context. Additionally, I conducted my research project while I was still working on a full-time basis, and the participants' academic

programme was in session. This posed a challenge in that I could only meet the students and facilitate their movement to the schools when they were 'free', so the time dedicated to the study was inevitably limited. Not all the implementing schools were in the proximity of my work place, so there was a need to facilitate transport to the various schools, which was costly.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

Since the research was only done on a small scale, I recommend the following:

- Conduct further research on how mobile phones could be used effectively across the teacher education curriculum in Zambia.
- Explore research possibilities in the incorporation of mobile technology into the school curricula that promote autonomous learning of Mathematics and other subjects.
- Conduct research with more research sites and a bigger sample size for the findings to be generalized to a wider context.
- Conduct research with other ICT devices, not only mobile phones.

5.7 PERSONAL REFLECTION

Prior to being involved in this study, I had opportunities to be involved in some research projects and presentations, but I have found the VITALmaths project to be most educative and helpful. Not only did this study enlighten me on the particular topic that I am studying, but it also equipped me with valuable insights into how to conduct educational research.

Interacting with VITALmaths video clips greatly helped me look with different lenses at my own perceptions about mobile technology in the classroom. Until I started building on my literature review of this study, I had a critical preconceived idea about the use of the mobile phone in the classroom, and assumed it could only be used to search for information if one had internet connectivity. However, after interacting with the VITALmaths clips on mobile phones, I came to realise its educational potential and I would advocate its wider use.

The experience I gained in this study will also encourage me to lobby and be involved in other research projects being fully convinced that I have a firm foundation on which I can build upon. I will strive to use the experiences to collaborate with other stakeholders and add to the VITALmaths database of video clips.

The demands of this project enlightened me on the importance of prioritising one's own work and managing time.

5.8 CONCLUSION

This chapter served as a conclusion to my research study. It provided a summary of my findings, and presented a brief discussion of the significance of the study and its limitations. It also provided recommendations based on the research findings, suggested areas for future research and finally, articulated my personal reflection regarding the entire study.

REFERENCES

Anderson, T. H. (2003) e-Research. Methods, Strategies and Issues. Boston: Pearson Education Inc.

Anderson-Levitt, K. M. (2006). Ethnography. In P. B. Elmore, G. Camilli & J. Green (Eds), *Handbook of complementary methods in education research* (279–298). Washington, DC and Mahwah, NJ: AERA & Lawrence Erlbaum Associates.

Arcavi, A. (2003). The role of visual representations in the learning of mathematics. *Educational studies in mathematics*, *52*(3), 215-241.

Arksey, H. & Knight, P. (1999). Interviewing for social scientists. London: Sage Publications

Asamu, P. (2015, November, 12). *Government remorseful over Grade 9 ICT Exam Chaos*. Zambia Reports, p. 12.

Attewell, J., & Savill-Smith, C. (2005). Mobile learning and social inclusion: focusing on learners and learning. Learning with mobile devices. *Research and development, 4*(2), 3-11.

Australasian Survey of Student Engagement Report (2009). *Doing More for Learning: Enhancing Engagement and Outcomes*. Melbourne/Sydney: The Australian Council for Educational Research (ACER).

Australian Education Council (1990*). A National Statement on Mathematics for Australian Schools*. Melbourne: Curriculum Corporation.

Babbie, E., & Mouton, J. (2001). *The practice of social research* (South African edition). Cape Town: Oxford University Press Southern Africa.

Barab, S., & Squire, K. (2004). Design-Based Research. Putting a Stake in the Ground. *The Journal of the Learning Sciences*, 13(1), 1-14.

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecologies perspective. *Human Development*, 1(49), 193–224.

Bates, T. (2005). *Technology, E-learning and Distance Education* (2nd ed.). Abingdon: Routledge.

Beetham, H. (2007) An Approach to Learning Activity Design. In H. Beetham & R. Sharpe (Eds.), *Rethiking Pedagogy for a Digital Age*. Oxon: Routledge

Bennett, S., Agostinho, S., Lockyer, L., Kosta, L., Joners, J., Koper, R., & Harper, B.(2007). *Learning Designs: Bridging the Gap Between Theory and Practice*. In

ICT: Providing Choices for Learners and Learning. Proceedings ASCILITE Singapore 2007 (pp.51-60).

Bertram, C., & Christiansen, I. (2015*). Understanding research. An introduction to reading research*. Pretoria: Van Schaik.

Beyers, R. N. (2009). A Five Dimensional Model for Educating the Net Generation. *Educational Technology & Society*, 12(4), 218-227.

Bishop, A. J. (1989). Review of research on visualization in mathematics education. *Focus on Learning Problems in Mathematics 11*(1), 7-16.

Bitter, G., & Pierson, M. (2002). Using technology in the classroom (5th ed.). Boston: Allyn & Bacon.

Bobis, J. (1996). *Visualisation and the development of number sense with kindergarten children. In Mulligan, J. & Mitchelmore, M. (Eds.) Children's Number Learning: A Research Monograph of the Mathematics Education Group of Australasia and the Australian Association of Mathematics Teachers*. Adelaide: AAMT

Bobis, J. (2008). Early Spatial Thinking and the development of Number Sense. *Australian Primary Mathematics Classroom, 13*(3), 4-9.

Boud, D. & Prosser, M. (2002). Appraising New Technologies for Learning. A Framework for Development. *Educational Media International, 39*, (3) pp.237-245.

Brick, A.J. (1989). *Research methodologies in science education: Visualization and the geosciences. Journal of Geoscience Education, 50*(4), 449-455.

Bruner, J. (1990). *Acts of meaning*, Cambridge: University Press

Burns, M. (2007). "How I Boost My Students' Number Sense." *Instructor Magazine* Apr. 1997: 49-54.

Burton, G. (1993). *Number sense and operations*. Reston, VA: National Council of Teachers of Mathematics

Chazan, D., & Schnepp, M. "*Methods, goals, beliefs, commitments, and manner in teaching: Dialogue against a calculus backdrop.*" Advances in Research on Teaching 9 (2002): 171-196.

Chen, J., Kinshuk, D. (2005). Mobile technology in educational services. *Journal of Educational Multimedia and Hypermedia*, 14 (1), 91–109.

Chickering, A., & Ehrmann, S.C. (Oct, 1997). *Implementing the Seven Principles: Technology as Lever. AAHE Bulletin*, pp. 3-6. Retrieved August 4 2015 from http://www.aahe.org/technology/ehrmann.html

Clark, R.E. (1994). Media will Never Influence Learning. *Education Technology Research Development, 53*(2), 21-30.

Cochrane, T. D. (2010). Exploring mobile learning success factors, ALT-J 18(2), 133-148.

Cohen, L., & Manion, L. (1994). *Research Methods in Education* (4th ed). London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2011). *Planning educational research. Research*

Cohen, L., Manion, L., & Morrison, K. (2011). Surveys, longitudinal, cross-sectional and trend studies. *Research Methods in Education,* 7th edition. Abingdon: Routledge, 261-4.

Cohen, L., Manion, L., Morrison, K., & Morrison, K. R. B. (2007). Content analysis and grounded theory. *Research methods in education*, 475-495.

Colella, V. (2000). Participatory Simulations: Building collaborative understanding through immersive dynamic modeling. *Journal of the Learning Sciences*, 9(4), 471-500.

Collins, A. M. (1992). Towards a design science of education. In E. Scanlon, & T. O'Shea (Eds.), *New directions in educational technology* (pp. 15-22). Berlin: Springer.

Conole, G., Dyke, M., Oliver, M. & Seale, J. (2004). Mapping pedagogy and tools for effective learning design. *Computers and Education*, 43, (2), 17-33.

Cooney, J.G. (2014). *Utilizing mobile technologies for classroom learning*. Retrieved March 5 2015 from http://www.qrcodescanning.com/mobile-technology-classroomlearning.html

Crapo, A. W. (2000). "Visualization and the process of modelling: a cognitive theoretic view." *Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining*. New York: ACM.

Creswell, J. W. (2007). Research design: *Qualitative, quantitative and mixed methods approaches* (2nd ed.) Thousand Oaks: Sage

Dabbagh, N. (2005) Pedagogical models for E-Learning: A theory-based design framework. *International Journal of Technology in Teaching and Learning*, 1(1), 25–44.

Denzin, N.K. & Lincoln, Y.S. (2005). Introduction: The Discipline and Practice of Qualitative Research In N.K. Denzin & Y.S. Lincoln (Eds.) *The SAGE Handbook of Qualitative Research.* (3rd). California: Sage Publications Inc.

Dreyfus, T., & Eisenberg, T. (1986). On the aesthetics of mathematical thought. *For the learning of mathematics, 6*(1), 2-10.

Duncan, A.S. (2006). An investigation into the influence of question design on pupils' approaches to number pattern generalisation tasks. Masters Research Proposal, Rhodes University, Education Department, Grahamstown.

Dunlap, J.C. & Grabinger, R.S. (1996). Rich Environments for Active Learning in the Higher Education Classroom. In B.G. Wilson (Ed.), *Constructivist Learning Environments. Case Studies In Instructional Design.* New Jersey: Educational Technology Publications.

Eiselen, R., & Uys, T. (2005). *Analysing survey data using SPSS 13: A Work book.* Johannesburg: RAU Pers

El-Hussein, M. O. M., & Cronje, J. C. (2010). Defining Mobile Learning in the Higher Education Landscape. *Educational Technology & Society, 13*(3), 12-21.

English, L. D. (Ed.). (2013). *Mathematical reasoning: Analogies, metaphors, and images.* Routledge.

Evans, L. & Abbot, I. (1998). *Teaching and Learning in Higher Education*. London: Wellington House.

Fullan, M. (2007). *The new meaning of educational change*. London: Routledge.

Garrison, D. R., & Anderson, T. (2003). *E-learning in the 21st century*. New York: Routledge Falmer.

Gersten, R., and D. Chard. (1999): "Number Sense: Rethinking Arithmetic Instruction for Students with Mathematical Disabilities. *The Journal of Special Education*, 3(1), 18-28.

Giesen, J. (2004). *Constructivism: A Holistic Approach for teaching and learning*. Illinois. Northern Illinois University.

Goos, M. (2010). Using technology to support effective mathematics teaching and learning: What counts? Retrieved October 23, 201, from http://research.acer.edu.au/cgi/viewcontent.cgi?article=1067&context=research_conference

Grade 9s forced to write exams past midnight. (2015, November 3). Lusaka Times, p. 1.

Gregorian, V., Hawkins, B.L., & Taylor, M. (1992). *Integrating Information Technologies: A Research University Perspective. CAUSE&EFFECT*, Winter 1992, pp. 2-12.

Guzman, M. (2002, July). *The role of visualization in the teaching of mathematical analysis. Paper presented at the International Conference on the Teaching Mathematics (at the undergraduate level).* Universidad Complutense de Madrid, Crete.

Hanna, G., & Sidoli, N. (2007). Visualisation and proof: a brief survey of philosophical perspectives. *ZDM, 39*(1-2), 73-78.

Hannafin, M. & Land, S. (1997). The foundations and assumptions of technology Hayes, P., Pathak, P., Joyce, D., & Hall, T. (2005). *Cultural-Context of Mobile Learning using Activity Theory*. In Proc. of the 6th Annual Irish Educational Technology Users' Conference.

Hannafin, M. J. (1992). Emerging Technologies, ISD, and Learning Environments: Critical Perspectives. *Educational Technology Research & Development*, 40(1), 49-63.

Hawkins, J. (1997). The National Design Experiments Consortium: Final Report. New York: Center for Children and Technology, Educational Development Center.high school mathematics. *Educational Studies in Mathematics* ,23, 595-610.

Hayes, P., Pathak, P., Joyce, D., & Hall, T. (2005). Mobile learning as technology mediated education: an 'activity' approach. International Association for Development of the Information Society (IADIS), *International Conference Mobile Learning*. pp. 231- 235

Haywood, T. (2016). *An exploration of learners' autonomous learning of mathematics by. Using selected Visual Technology for the Autonomous Learning of Mathematics(VITALmaths) video clips: A case study*. Master of Education Thesis. Rhodes University. Grahamstown

Ho, S. Y. (2010). *Seeing the value of visualization. Mathematics and Mathematics. Education Academic Group, National Institute of Education*, Singapore: Nanyang Technological University

Huang, Y. M., Huang, T. C., & Hsieh, M. Y. (2008). Using Annotation Services in a Ubiquitous Jigsaw Cooperative Learning Environment. *Educational Technology & Society,11*(2), 3-15.

Hyde, C.J. (2011). *An investigation into the use Visual Technology for Autonomous Learning (VITALmaths) video clips through the medium of cell phones in the teaching of mathematics in selected South African Grade 9 classes: A case study. Grahamstown, South Africa*. Master of Education Thesis. Rhodes University. Grahamstown.

IOB. (2011). *Unfinished Business: Making a Difference in Basic Education, an Evaluation of impact of education policies in Zambia and the role of budget support. IOB Evaluation No 352*. The Hague: The Netherlands Ministry of Foreign Affairs

Järvelä, S., Naykki, P., Laru, J., & Luokkanen, T. (2007). Structuring and regulating collaborative learning in higher education with wireless networks and mobile tools. *Educational Technology & Society*, 10(4), 71-79.

JISC (2004). *The e-learning advantage. Effective practice with e-learning*. Retrieved February 24, 2015 from http://www.elearning.ac.uk/effprac/html/e_intro.htm

John, P. & Sutherland, R. (2005). Affordance, Opportunity and the Pedagogical Implications of ICT. Educational Review, 57(4), 405 -413.

Kadunz, G., & Sträßer, R. (2004). Image-metaphor-diagram: Visualisation in learning mathematics. *In Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education (4),* pp. 241-248).

Kalchman, M., Moss, J., & Case, R. (2001). Psychological models for the development of mathematical understanding: Rational numbers and functions. In S. Carver & D.Klahr (Eds.), *Cognition and Instruction*. Mahwah, NJ: Lawrence Erlbaum.

Kalimaposo, K, K. *(2010). The impact of curriculum innovations on pre-service primary education in Zambia. Unpublished doctoral thesis, University of Zambia, Lusaka*

Kaphesi, E. (2003). *The influence of language policy in education on mathematics classroom discourse in Malawi: the teachers' perspective*. Teacher Development, 7(2), 265-285.

Kelly, M.J. (1999). *The Origins and Development of Education in Zambia*: From Pre Colonial Times to 1996. Lusaka: Image Publishers

Kennedy, G., Krause, K. L., Judd, T., Churchward, A., & Gray, K. (2006). First YearStudents' Experience with Technology: Are the Really Digital Natives? Preliminary Report of Findings. Melbourne: Centre for Study of Higher Education, The University of Melbourne. Retrieved August 25 2016 from http://www.bmu.unimelb.edu.au/research/munatives/natives_report2006.rtf

Kilpatrick, J. (1988). *Change and stability in research in mathematics education. Zentralblatt fur Didaktik der Mathematik, (20)*, 202-204.

Kilpatrick, J. Swafford, J. & Findell, B.(eds.)(2001). *Adding it up: Helping children learn mathematics*. Mathematics Learning Study Committee: National Research Council.

Kiwala, F.M. (2014, September). 2013 Chief examiner's reports in Mathematics. Paper presented at the 2014 Zambia Association of Mathematics Education, Mpelembe secondary school, Kitwe.

Klein, H.K. & Myers, M.D. (1999). *A Set of principles for conducting and evaluatin interpretive filed studies in information systems*. MIS Quarterly, 23(1), 67-94.

Koebler, J. (2011). *Teachers use cell phones in the classroom*. Retrieved 17 August 2015 from http://www.usnews.com/education/blogs/high-school-notes

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Kukulska-Hulme, A. (2005). Mobile Usability and User Experience. In A. KukulskaHulme & J. Traxler, J. (Eds.) *Mobile Learning: A Handbook for Educators And Trainers*, (1), 45-56. London: Routledge.

Kukulska-Hulme, A., and de los Arcos, B. (2011). *Triumphs and frustrations of self motivated language learners using mobile devices. Proceedings of the CAL Conference 2011 - Learning Futures: Education, Technology & Sustainability.* Retrieved May 5, 2014from http://oro.open.ac.uk/28707/

Lester, F. (2005). On the theoretical, conceptual, and philosophical foundations for research in mathematics education. *Zentralblatt fuer Didaktik der Mathematik, 37(6)*, 457-467.

Linneweber-Lammerskitten, H., Schäfer, M., & Samson, D. (2010*). Visual technology for the autonomous learning of mathematics. Pythagoras, (72)*, 27-35.

Linneweber-Lammerskitten, H., Schäfer, M., & Samson, D. (2010). *Visual technology for the autonomous learning of mathematics. Pythagoras, (72)*, 27-35.

Linneweber-Lammerskitten, H., Schäfer, M., & Samson, D. (2011). VITAL Maths: Visual Technology for the Autonomous Learning of Mathematics. In S. Chunawala & M. Kharatmal (Eds.), Proceedings of episteme 4 – *International Conference to Review Research on Science, Technology and Mathematics Education* (pp. 353-357). Mumbai, India: Macmillan.

Linneweber-Lammerskitten., & Schäfer, M. (2010). Motivating mathematical exploration through the use of video-clips: a collaborative research and development project between Switzerland and South Africa. In V. Mudaly (Ed.), *Proceedings of the eighteenth Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education* (pp. 161–164). University of Kwazulu-Natal: SAARMSTE.

Looi, C. (2009). One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning, 1*(1), 3-29. Retrieved October 7 2016 from http://ctl.sri.com/publications/displayPublication.jsp?ID=439

Low, L., & O'Connell, M. (2006, October). Learner-centric design of digital mobile learning. *In Proceedings of the OLT Conference* (pp. 71-82).

Makina, A. (2010). *The role of visualisation in developing critical thinking in mathematics. Perspectives in Education, 28*(1), 24-33.

Mayer, R.E. & Moreno, R. (2002). *Animations as an aid to multimedia learning*. Retrieve September 28 2015 from http://ydraw.com/wp-content/uploads/2012/04/Stop-Motion- Aids Multimedia-Learning.pdf

Mayes, T., Morrison, D., Mellar, H., Bullen, P., & Oliver, M (Eds.), *Transforming Higher Education Through Technology-Enhanced Learning*. York: The Higher

McMillan, J.H., & Schumacher. (1993). Research in education. A conceptual framework. New York: Longman

Mesaroš, M. (2011). *The teaching of combinatorics and probability using statistics. In: forum Mobile Technologies in Education*. Stockholm: Vaxjo.

methods in education. New York: Routledge Editors.

MobiLearn Project. Retrieved May 28 2015 from www.mobilearn.org/download/results/public_deliverables/MOBIlearn_D4.4_Final.pdf

Mudaly, V. (2010). *Thinking with diagrams whilst writing with words. Pythagoras, (71),* 65-75.

Nardi, B., & Schwarz, H. (2002). NetWORKers and their Activity in Inten-tional Networks. *The Journal of Computer-supported Cooperative Work*, 1 (2)205–242.

National Centre for Research Methods. (2015). NCRM.. London Routledge

National Council of Teachers of Mathematics (2000). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). Principles and Standards for School Mathematics. Reston, VA: NCTM.

National Union of Student. (2010). *Student perspectives on technology - demand, perceptions and training needs, report to HEFCE by NUS*. Retrieved July 8 2015 from http://www.hefce.ac.uk/media/hefce/content/pubs/2010/rd1810/rd18_10.pdf

Ndafenongo, G. (2011). *An investigation into how cell phones can be used in the teaching of mathematics using VITALmaths video clips: A case study of two schools in Grahamstown, South Africa*. Master of Education Thesis. Rhodes University. Grahamstown.

Nemirovsky, R., & Noble, T. (1997). On mathematical visualization and the place where we live. *Educational Studies in Mathematics, 33*(2), 99-131.

Newby, P. (2010). *Research methods for education*. Cape Town: Pearson.

Nieuwenhuis, J. (2011). Qualitative research designs and data gathering techniques. In K. Maree (Ed.), *First steps in research* (8th ed.) (pp. 69-97). Pretoria: Van Schaick Publisher

Nyiri, K. (2002). Towards a Philosophy of M-Learning. *IEEE International Workshop on Wireless and Organisation, 1* (1), 81-102.

Oblinger, D. G., & Oblinger, J. L. (2005*). Educating the net generation*. EDUCAUSE. Retrieved May 2011 from http://www.educause.edu/educatingthenetgen/

O'Driscoll, M. P., & Randall, D. M. (1999). Perceived organisational support, satisfaction with rewards, and employee job involvement and organisational commitment. *Applied Psychology, 48*(2), 197-*209.*

Okello, N.P. (2010). Learning and teaching college algebra at university level: Challenges and opportunities: A case study of USIU. The Journal of Language, technology and entrepreneurship in Africa, 2(101), 1998-1279

Oliver, R. (2002). The role of ICT in higher education for the 21st century: ICT as a change agent for education. Retrieved September 22 2009 fromhttp://elrond.scam.ecu.edu.au/oliver/2002/he21.pdf

Oliver, R., Harper, B., Wills, S., Agostinho, S., & Hedberg, J. (2007). Describing ICT-based learning designs that promote quality learning outcomes. In H. Beetham & R. Sharpe (Eds.), Rethinking Pedagogy for a Digital Age. Designing and delivering e-learning (pp. 64-80). London, New York: Routledge

Osborne, J. (2011). Why knowing what's wrong matters as much as knowing what's right. In S. Chunawala & M. Kharatmal (Eds.), Proceedings of epiSTEME 4 — *International Conference to Review Research on Science, Technology and Mathematics Education* (pp. 18 19).

Papert, S. (1990). An Introduction to the Fifth Anniversary Collection. In I, Harel (Ed.), *Constructivist Learning*. Cambridge, MA: MIT Media Laboratory.

Passey, D. (2010). Mobile learning in school contexts: can teachers alone make it happen. Iin Proc. *IEEE Transactions on Learning Technologies*, 3(2),1-14.

Perry, B., Geoghegan, N., Howe, P., & Owens, K. (1995). *Cooperative learning and social constructivism in mathematics education*. Retrieved April 16, 2015, from http://www.merga.net.au/documents/RP_Perry_Geoghegan_Owens_Howe_199 5.pdf

Peters, K. (2007). m-Learning: Positioning educators for a mobile, connected future. International. *Journal Of Research in Open and Distance Learning*. 8(2), pp.1-17.

Pettit, J. & Kukulska-Hulme, A. (2007). Going with the grain: Mobile devices in practice. *Australasian Journal of Educational Technology, 23*(1), 1-13. Retrieved February 19 2015 from http://www.ascilite.org.au/ajet/ajet23/pettit.html

Piaget, J. (1967). Biology and knowledge. Edinburgh: Edinburgh University Press

Plenderleith, J., & Adamson, V. (2009). The Policy Landscape of Transformation. In Mayes, T., Morrison, D., Mellar, H., Bullen, P., & Oliver, M (Eds.), *Transforming Higher Education Through Technology-Enhanced Learning*. York: The Higher Education Academy

Plowman, L. (2004). *Using video for observation interaction in the classroom*. Retrieved July 29 2015 from http://www.scre.ac.uk/spotlight/spotlight72.html.

Prensky, M. (2005). *What Can You Learn from a Cell Phone? Almost Anything*. Retrieved June 2 4, 2011, from http://www.innovateonline.info/pdf/vol1_issue5/What_Can_You_Learn_from_a_ Cell_Phone__Almost_Anything!.pdf

Prensky, M. (2006). *Don't bother me, Mom, I'm learning!: How computer and video games are preparing your kids for 21st century success and how you can help*!. St. Paul, MN: Paragon house

Prensky, M. (2006). *Listen to the Natives. Educational Leadership 63*(4), pp. 8-13. Retrieved on March 29, 2015 from http://centre4.interact.ac.nz/viewfile.php /users/38/1965011121/ICT_PD_Online/ListentotheNatives.pdf.

Presmeg, N. C. (1992). *Prototypes, metaphors, metonymies and imaginative rationality in high school mathematics. Educational studies in mathematics, 23*(6), 595-610.

Presmeg, N. C. (2006). *Research on visualization in learning and teaching mathematics. Handbook of research on the psychology of mathematics education*, 205-235.

Pring, R. (2000). *Philosophy of educational research*. London: Continuum.

Qiao, A., Sun, L., & Wang, N. (2009) .The Design of Web-based Learning Activities: A Case Study on Learning Activities Design from Mainland China. ICCSIT 2nd IEEE International Conference 8-12 Aug, Computer Science and Information Technology 2009, pp.126-129.

Reys, R. E. & Yang, D. C. (1998). Relationship Between Computational Performance and Number Sense Among Sixth and Eighth Grade Students in Taiwan, Journal for Research in Mathematics Education, 29 (2), 225-237.

Rogers, Y., Price, S., Fitzpatrick, G., Fleck, R., Harris, E., Smith, H., & Thompson, M. (2004, June). Ambient wood: designing new forms of digital augmentation for learning outdoors. *In Proceedings of the 2004 conference on Interaction design and children: building a community* (pp. 3-10). ACM.

Ruane, J.M. (2005). *Essentials of research methods: a guide to social science research*. Brisbane: Queensland University Press.

Rule, P. & John, V. (2011). Your guide to case study research. Pretoria: Van Schaik. SAGE. Retrieved January 23, 2014, from (http://www.bul.sagepub.com/cgi/content/abstract/89/642/24)

Schafer, M. (2015). Visualisation in Namibia and Zambia project 2015. Concept document Rhodes University, Education Department, Grahamstown

Selwyn, N. (2007). The use of computer technology in university teaching and learning: a.critical perspective. *Journal of Computer Assisted Learning, 23*(2), pp.83–94

Sharples, M. (2000). *The Design of Personal Mobile Technologies for Lifelong Learning. Computers & Education,* 32, pp. 177-193.

Sharples, M. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing*, 6(1), 220–234

Sharples, M. (Ed.). (2006). Big issues in mobile learning. Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative, University of Nottingham, UK. Retrieved March 2009 from http://hal.archivesouvertes.fr/docs/00/19/02/54/PDF/Sharples_Big_Issues.pdf

Shuler, C. (2014). *Pockets of potential: Using mobile learning technologies to promote children's learning. New York: The Joan Ganz Cooney Center at Sesame Workshop.* Retrieved May 17, 2015 from http://www.scribd.com/doc/62873954/1/introductionmaking-the-case-for-mobile-learning

Silverman, D. (1993). Interpreting qualitative data: Strategies for analysing talk, text and *interaction*. London: Sage.

So, H. J. & Kim, B. (2008). Teaching and learning with mobile technologies: educational applications. In M. Pagani (Ed.), *The encyclopaedia of multimedia technology and networking. Hershey, PA: Information Science Reference*, 1366–1372.

Somekh, B. (2007). *Pedagogy and Learning with ICT. Researching the Art of Innovation*. Oxon: Routledge.

Sowder, J. (1988). Mental computation and number comparison: Their roles in the development of number sense and computational estimation. In J. Hiebert & M. Behr (Eds*), Research Agenda for Mathematics Education: Number Concepts and Operation in the Middle Grades* (pp. 192–197). Operation in the Middle Grades (pp. 192–197). Reston, VA: National Council of Teachers of Mathematics

Squire, K. & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences*, 16,(3)371–413.

Stahl, G. (2000). Collaborative information environments to support knowledge construction by communities. *AI Society*, 14(2), 71–97.

Stylianou, D. A., & Silver, E. A. (2004). *The role of visual representations in advanced mathematical problem solving: An examination of expert-novice similarities and differences. Mathematical thinking and learning, 6*(4), 353-387.

Taylor, B., Sinha., G., & Ghoshal, T.(2011). *Research Methodology- A guide for Researchers in Management & social sciences*. (5th). New Delhi: Prentice Hall.

Terre Blanche, M., & Durrheim, K. (1999). Interpretive methods. In M. Terre Blanche & K.Durrheim (Eds.), *Research in practice: Applied methods for the social sciences*. Cape Town: University of Cape Town Press.

Thomas, S. (2005). *Pervasive, persuasive eLearning: Modeling the pervasive learning space*. Proceedings of the 3rd international conference on pervasive computing and communications workshops (PERCOMW'05) (pp. 332–336). Kauai Island, Hawai'i: IEEE Computer Society.

Thornton, S. (2001). *A picture is worth a thousand words. In New ideas in mathematics education: Proceedings of the International Conference of the Mathematics Education into the 21st Century Project* (pp. 251-256).

Traxler, J. (2007). Defining, Discussing and Evaluating Mobile Learning: The moving finger writes. *The International Review of Research in Open and Distributed Learning, 8*(2).

Urquhart, C. (2013). *Grounded theory for qualitative research: practical guide*: Los Angeles: Sage Publications.

Vavoula, G. (2009). Issues and Requirements for Mobile Learning Research. In Vavoula, G., Pachler, N., and Kukulska-Hulme, A. (Eds.) (2009) *Researching Mobile Learning. Framework, Tools and Research Designs*. Bern: Peter Lang AG.

Warger, T., & Dobbin, G. (2009). Learning environments: Where space, technology, and culture converge. ELI White Papers, *EDUCAUSE Learning Initiative*. Retrieved January 5 2016 from http://www.educause.edu/Resources/LearningEnvironmentsWhereSpace/ 188507

Whitely, W. (2004). Visual form is mathematics: Thinking, communicating, learning. Retrieved August 4, 2014, from http://link.springer.com/chapter/10.1007%2F1-4020- 7910-9_56?I_I=true#page-1

Wilensky, U. (1991). Abstract meditations on the concrete and concrete implications for mathematics education In I. Harel & S. Papert, (Eds.), Constructionism (pp. 193–203). Norwood, NJ: Ablex Publishing Corporation.

Wilson, B. G., & Cole, P. (1996). Cognitive Teaching Models. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology*. London: Prentice-Hall International.

Wittrock, M., ed. (1977). *Learning and instruction*. Berkeley, CA: Mc Cutchan.

World Statistics: *Usage and Population Statistics. Retrieved from* http://www.internet-worldstats.com/stats.htm on April 1, 2016

***Zambia* Telecoms, Mobile and Broadband** - *Statistics and Analyses*. (2015) Retrieved on 28 August 2015 from http://www.budde.com.au/Research/Zambia-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses.html

Zambia, Ministry of Education. (2012). *Examination Council of Zambia. Lusaka*: ECZ

Zambia, Ministry of Education. (2014). *The Zambia Education Curriculum Framework. Lusaka*: Curriculum Development Centre.

Zambia. Central Statistical Office. (2010). *2010 Analytical Report*. Lusaka: CSO.

Zambia. Ministry of Education. (1996). *Educating Our Future. National Policy on Education*. Lusaka. Government Printers

Zambia. Ministry of Education. (2007). Draft Information and Communication. Lusaka Government Printers

Zambia. Ministry of Education. (2012). The Zambia Education Curriculum Framework. Lusaka: Curriculum Development Centre.

Zambia. Ministry of Education. (2013). *Revised Curriculum. Grade 1-7*. Lusaka: Curriculum Development Centre.

Zambia. Ministry of Education. (2014). *National Numeracy Framework Draft*. Lusaka: Curriculum Development Centre.

Zambia. Ministry of Education. (2015). *National Implementation Framework*. Lusaka: Government Printers.

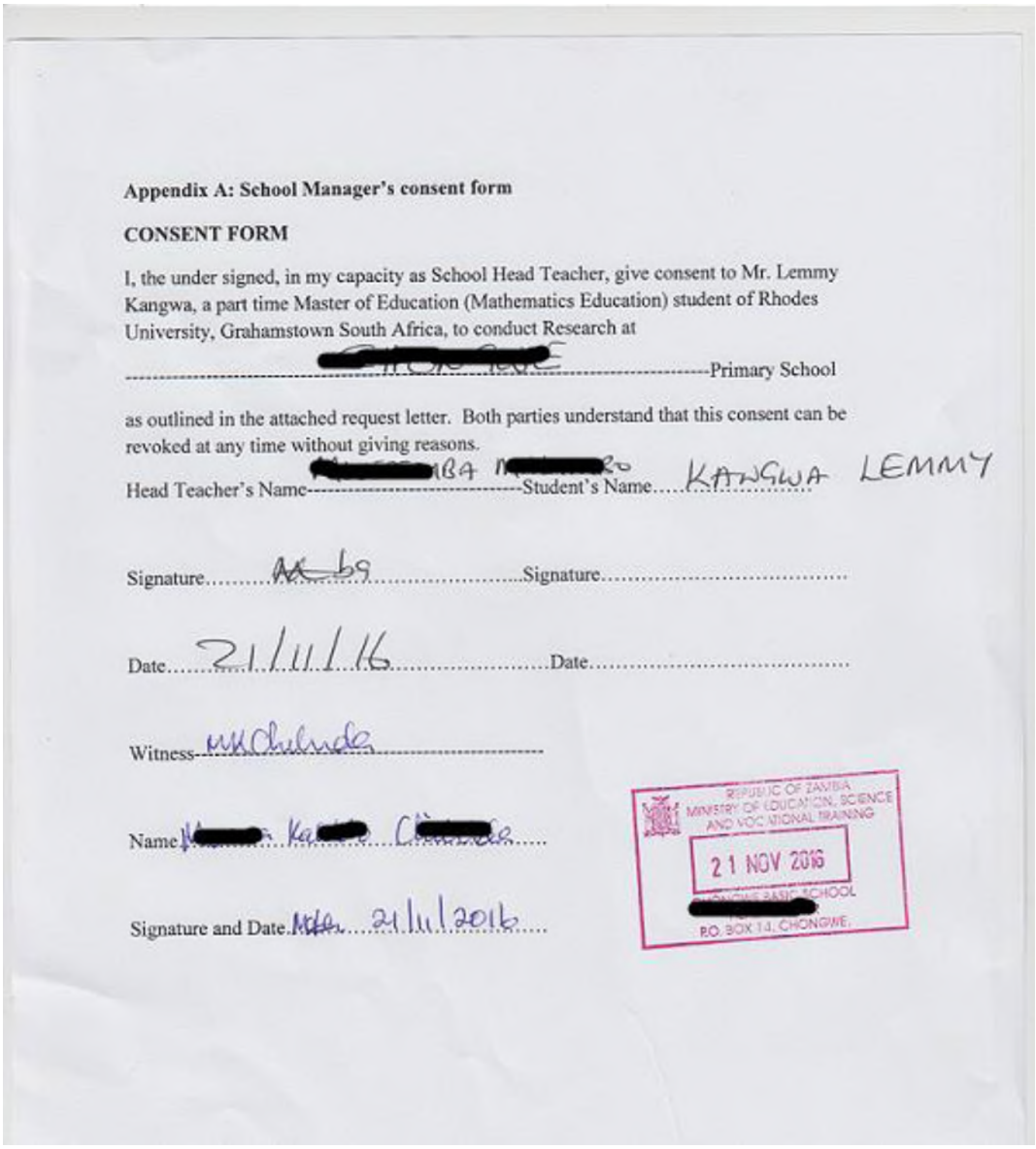
Zaslavsky, O., & Sullivan, P. (Eds). (2011). Constructing knowledge for teaching secondary mathematics. London: Springer

Zawacki-Richter, O., Brown, T., & Delport, R. (2007). Factors that may contribute to the establishment of mobile learning in institutions – Results from a Survey. International *Journal of Interactive Mobile Technologies (iJIM), 1*, (1), 4044.

Zimmermann, W., & Cunningham, S. (Eds.). (1991). *Visualization in teaching and learning mathematics (pp. 127-137). Washington DC: Mathematical Association of America*.

APPENDIX A: SCHOOL MANAGER CONSENT FORM

School Manager 1



Appendix A: School Manager's consent form

CONSENT FORM

I, the under signed, in my capacity as School Head Teacher, give consent to Mr. Lemmy Kangwa, a part time Master of Education (Mathematics Education) student of Rhodes University, Grahamstown South Africa, to conduct Research at

[redacted]Primary School

as outlined in the attached request letter. Both parties understand that this consent can be revoked at any time without giving reasons.

Head Teacher's Name[redacted]Student's Name....KANGWA LEMMY

Signature.....Signature.....

Date....21/11/16.....Date.....

Witness MK Chilinda

Name [redacted]

Signature and Date 21/11/2016

REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION, SCIENCE AND VOCATIONAL TRAINING
21 NOV 2016
[redacted] BASIC SCHOOL
P.O. BOX 1J, CHONGWE.

APPENDIX A:

School Manager 2

Appendix A: School Manager's consent form

CONSENT FORM

I, the under signed, in my capacity as School Head Teacher, give consent to Mr. Lemmy Kangwa, a part time Master of Education (Mathematics Education) student of Rhodes University, Grahamstown South Africa, to conduct Research at

[redacted]----------Primary School

as outlined in the attached request letter. Both parties understand that this consent can be revoked at any time without giving reasons.

D/Head Teacher's Name-[redacted]----------Student's Name……

Signature……Signature……

REPUBLIC OF ZAMBIA MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING & EARLY EDUCATION 18 NOV 2016 DEPUTY HEADTEACHER [redacted] BASIC SCHOOL PRIVATE BAG E1, LUSAKA

Date……Date……

Witness----------

Name……

Signature and Date……18/11/16

APPENDIX A:

School Manager 3

Appendix A: School Manager's consent form

CONSENT FORM

I, the under signed, in my capacity as School Head Teacher, give consent to Mr. Lemmy Kangwa, a part time Master of Education (Mathematics Education) student of Rhodes University, Grahamstown South Africa, to conduct Research at

[redacted]----------Primary School

as outlined in the attached request letter. Both parties understand that this consent can be revoked at any time without giving reasons.

Head Teacher's Name[redacted]----------Student's Name KANGWA LEMMY

Signature.....Signature.....

Date 01.03.16 Date.....

Witness MUTEBA RITAH

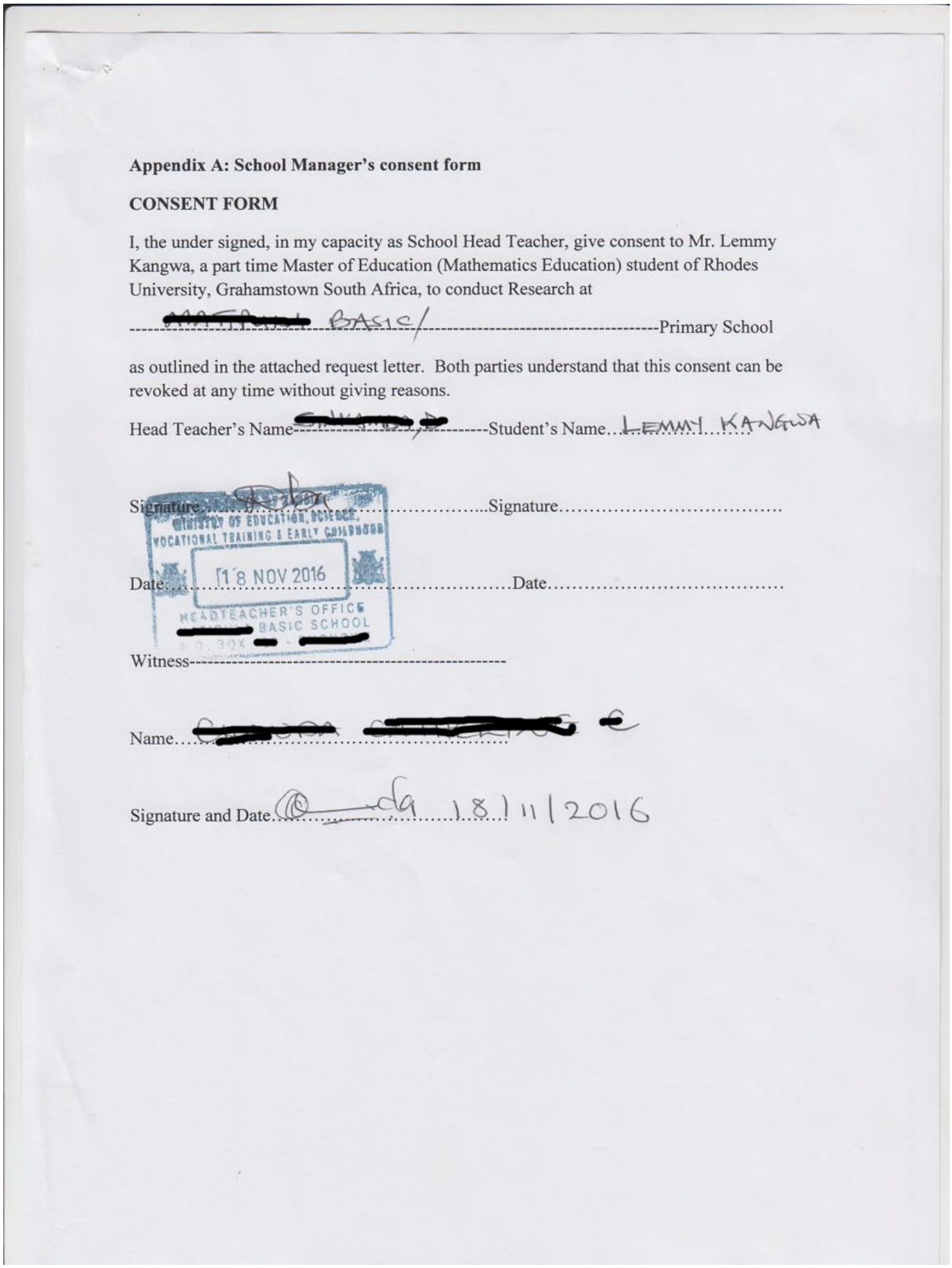
REPUBLIC OF ZAMBIA MINISTRY OF EDUCATION SCIENCE, VOCATIONAL TRAINING & EARLY EDUCATION 01 MAR 2016 [redacted] HEAD TEACHER PRIMARY SCHOOL P.O. BOX 191, CHONGWE

Name.....

Signature and Date.....01.03.16

APPENDIX A:

School Manager 4



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[redacted] BASIC/----------Primary School

as outlined in the attached request letter. Both parties understand that this consent can be revoked at any time without giving reasons.

Head Teacher's Name[redacted]----------Student's Name…LEMMY KANGWA……

Signature……..Signature……

MINISTRY OF EDUCATION, SCIENCE, VOCATIONAL TRAINING & EARLY CHILDHOOD
18 NOV 2016
HEADTEACHER'S OFFICE
[redacted] BASIC SCHOOL
P.O. BOX [redacted]

Date……Date……

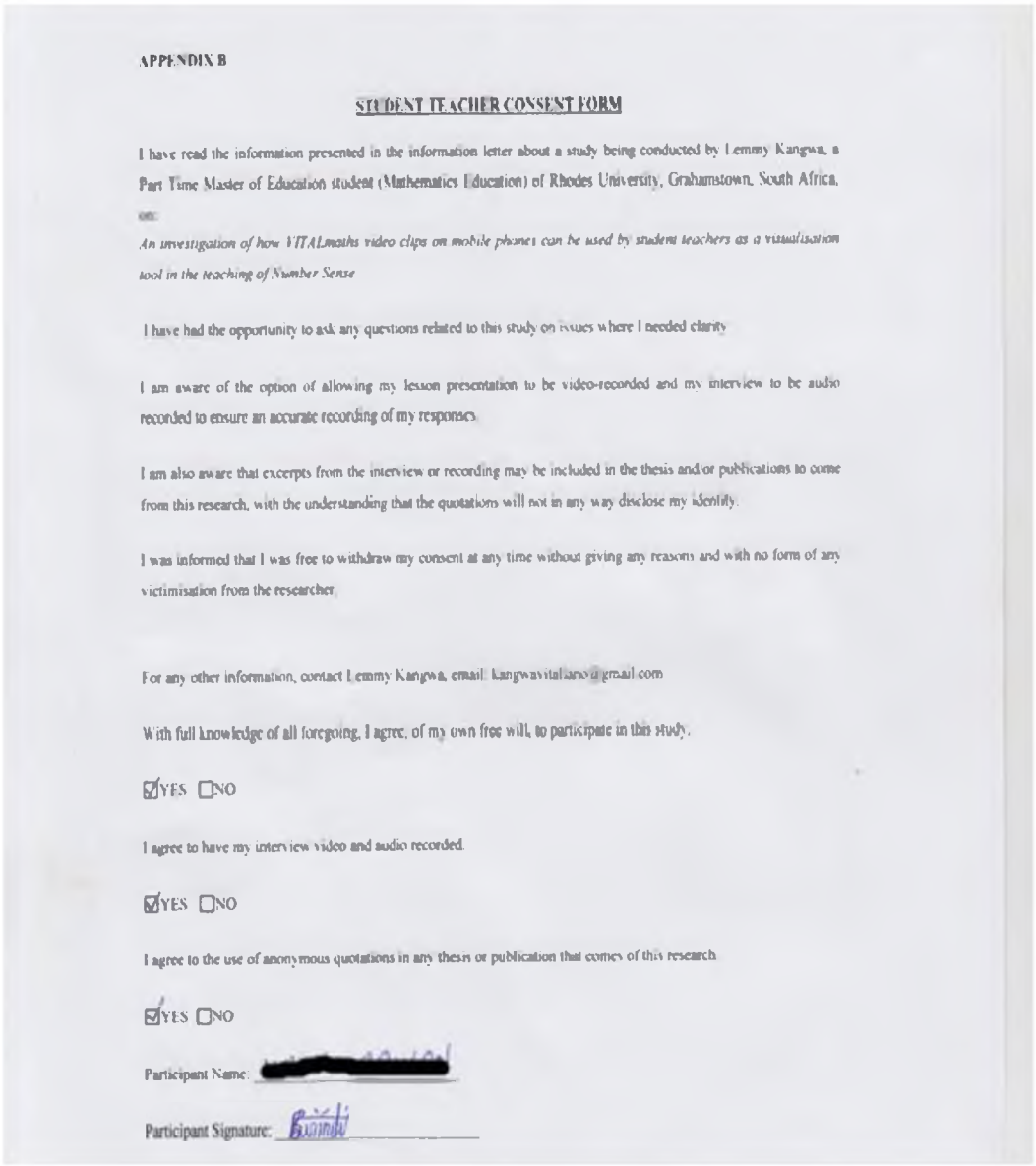
Witness----------

Name…[redacted]

Signature and Date……18/11/2016

APPENDIX B: STUDENT TEACHER CONSENT FORM

Student Teacher 1



APPENDIX B

STUDENT TEACHER CONSENT FORM

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An investigation of how VITALmaths video clips on mobile phones can be used by student teachers as a visualisation tool in the teaching of Number Sense

I have had the opportunity to ask any questions related to this study on issues where I needed clarity.

I am aware of the option of allowing my lesson presentation to be video-recorded and my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview or recording may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will not in any way disclose my identity.

I was informed that I was free to withdraw my consent at any time without giving any reasons and with no form of any victimisation from the researcher.

For any other information, contact Lemmy Kangwa, email: kangwavitalians@gmail.com

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☑YES ☐NO

I agree to have my interview video and audio recorded.

☑YES ☐NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

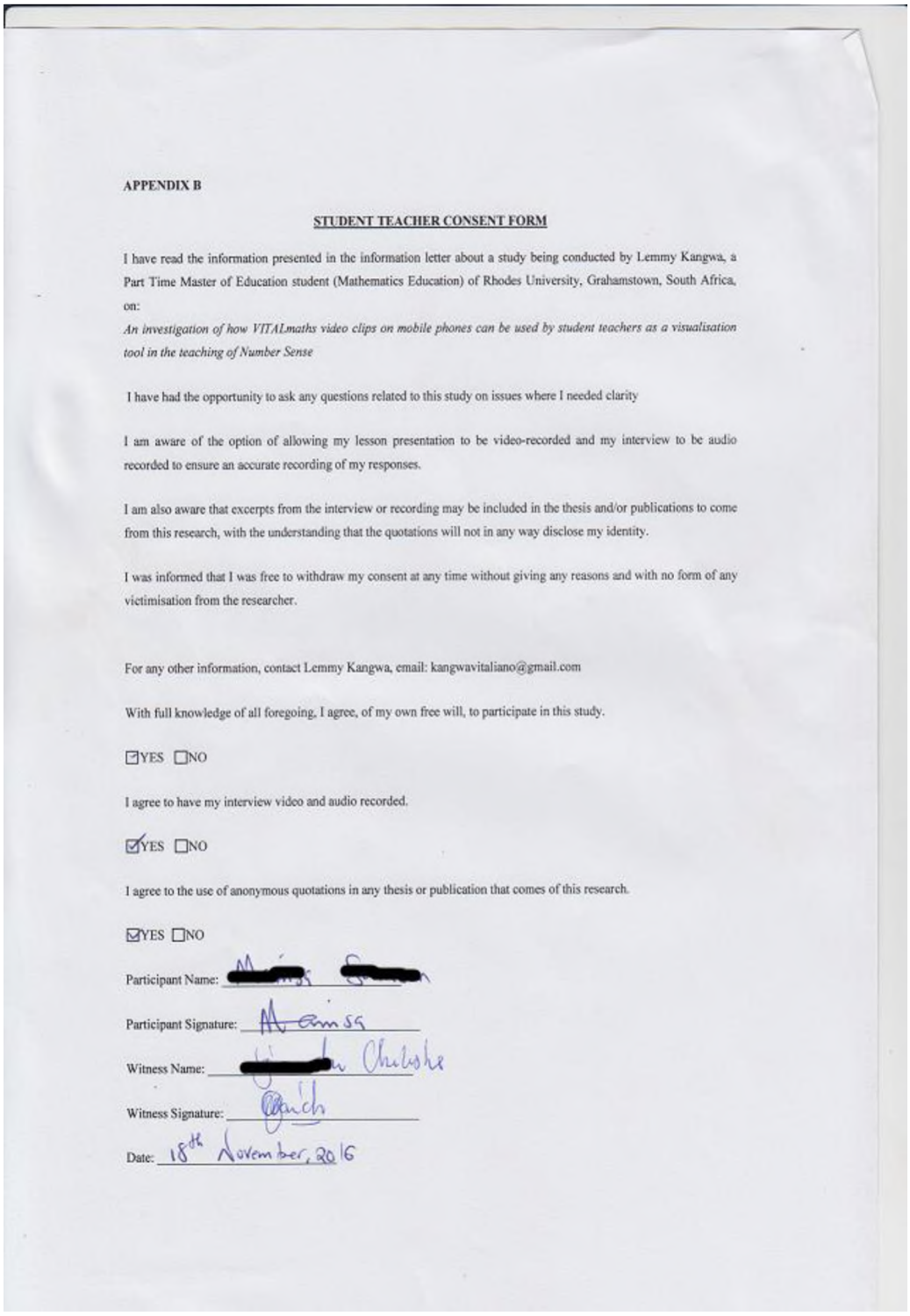
☑YES ☐NO

Participant Name: [redacted]

Participant Signature: _____

APPENDIX B

Student Teacher 2



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I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☑YES ☐NO

Participant Name: [redacted]

Participant Signature: [redacted]

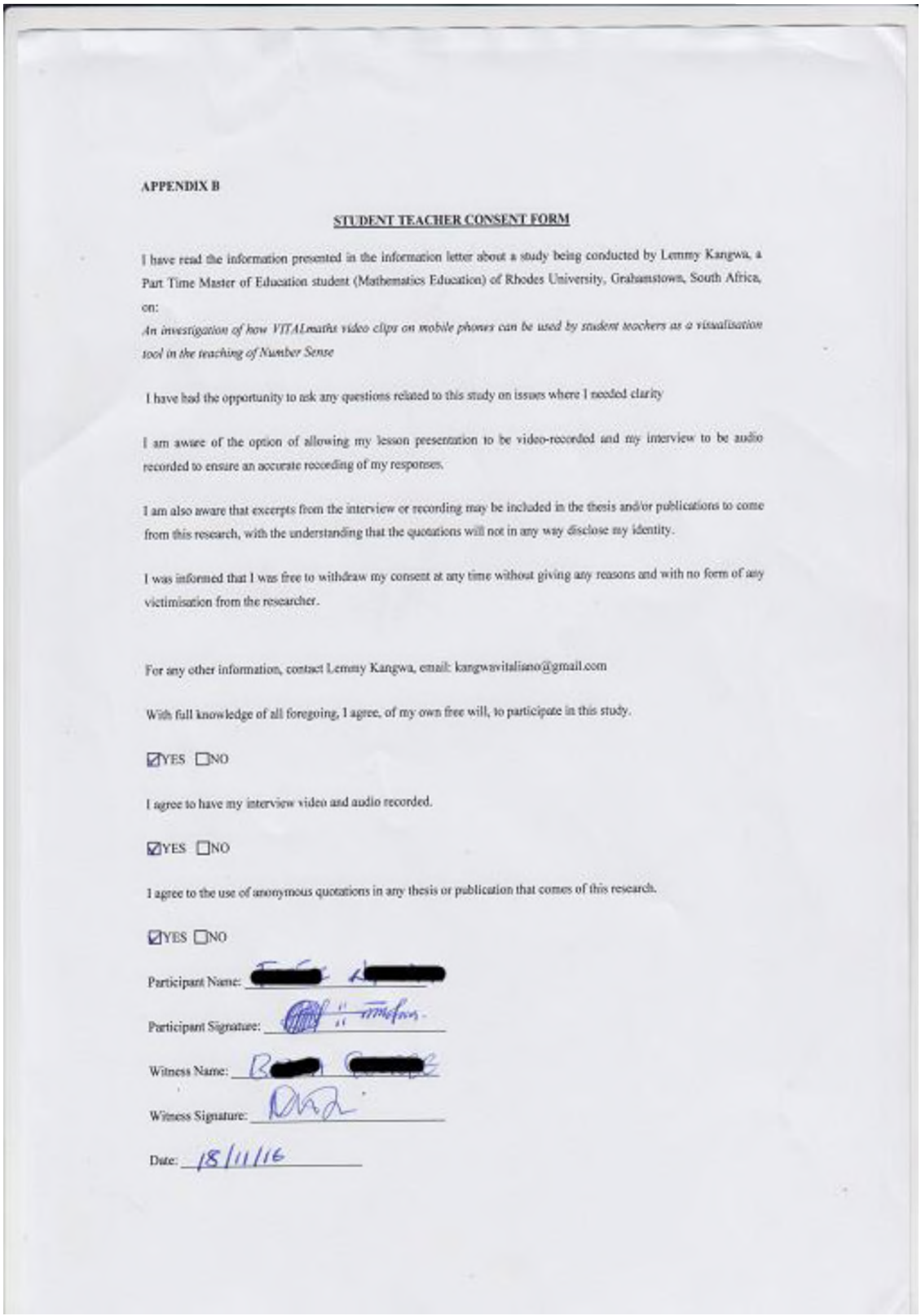
Witness Name: [redacted] Chileshe

Witness Signature: [redacted]

Date: 18th November, 2016

APPENDIX B

Student Teacher 3



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☑YES ☐NO

Participant Name: [redacted]

Participant Signature: [redacted]

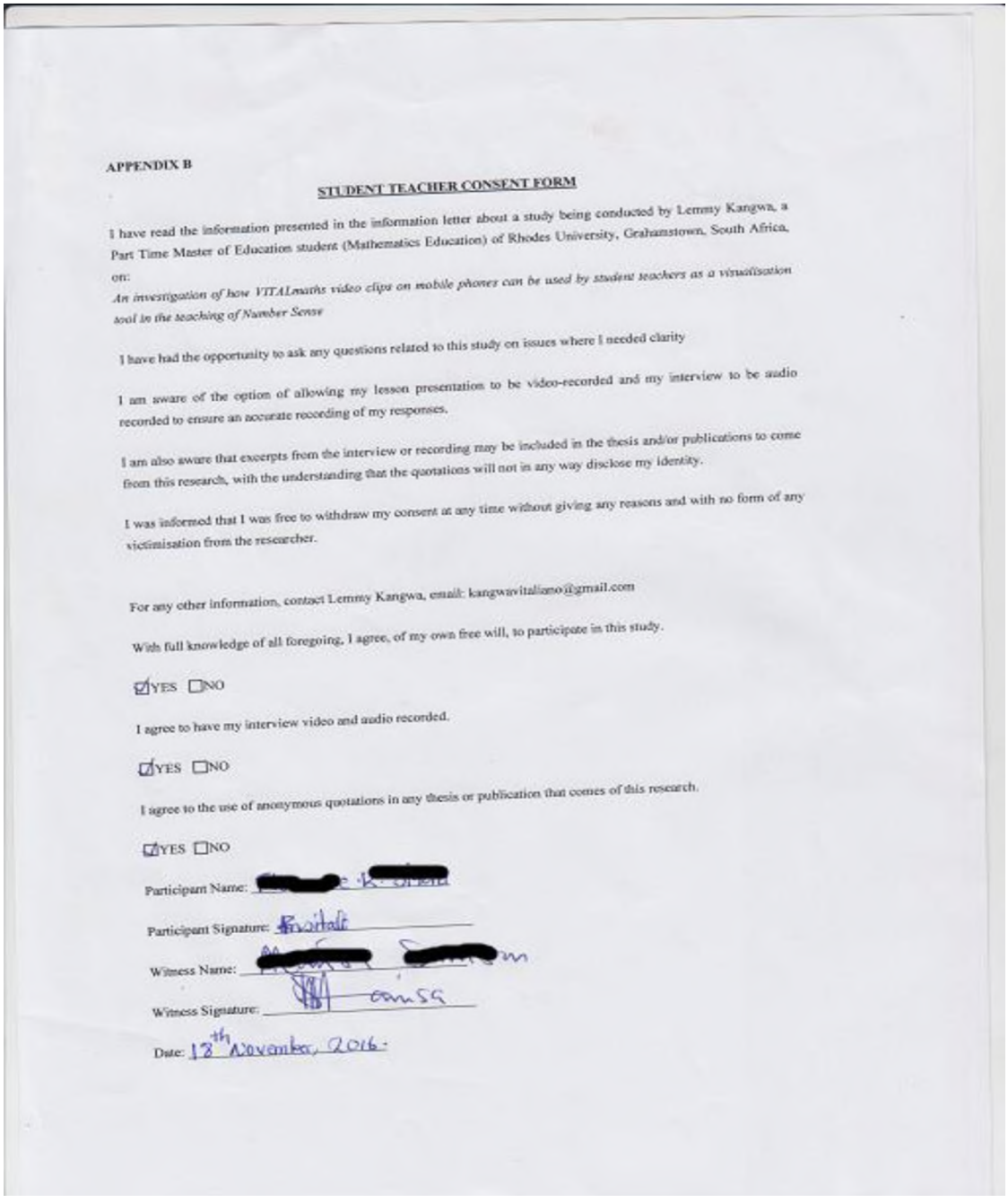
Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18/11/16

APPENDIX B

Student Teacher 4



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☑YES ☐NO

Participant Name: [redacted]

Participant Signature: [redacted]

Witness Name: [redacted]

Witness Signature: [redacted]

Date: 13th November, 2016.

APPENDIX B

Student Teacher 5

APPENDIX B

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I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☑YES ☐NO

Participant Name: [redacted]

Participant Signature: [redacted]

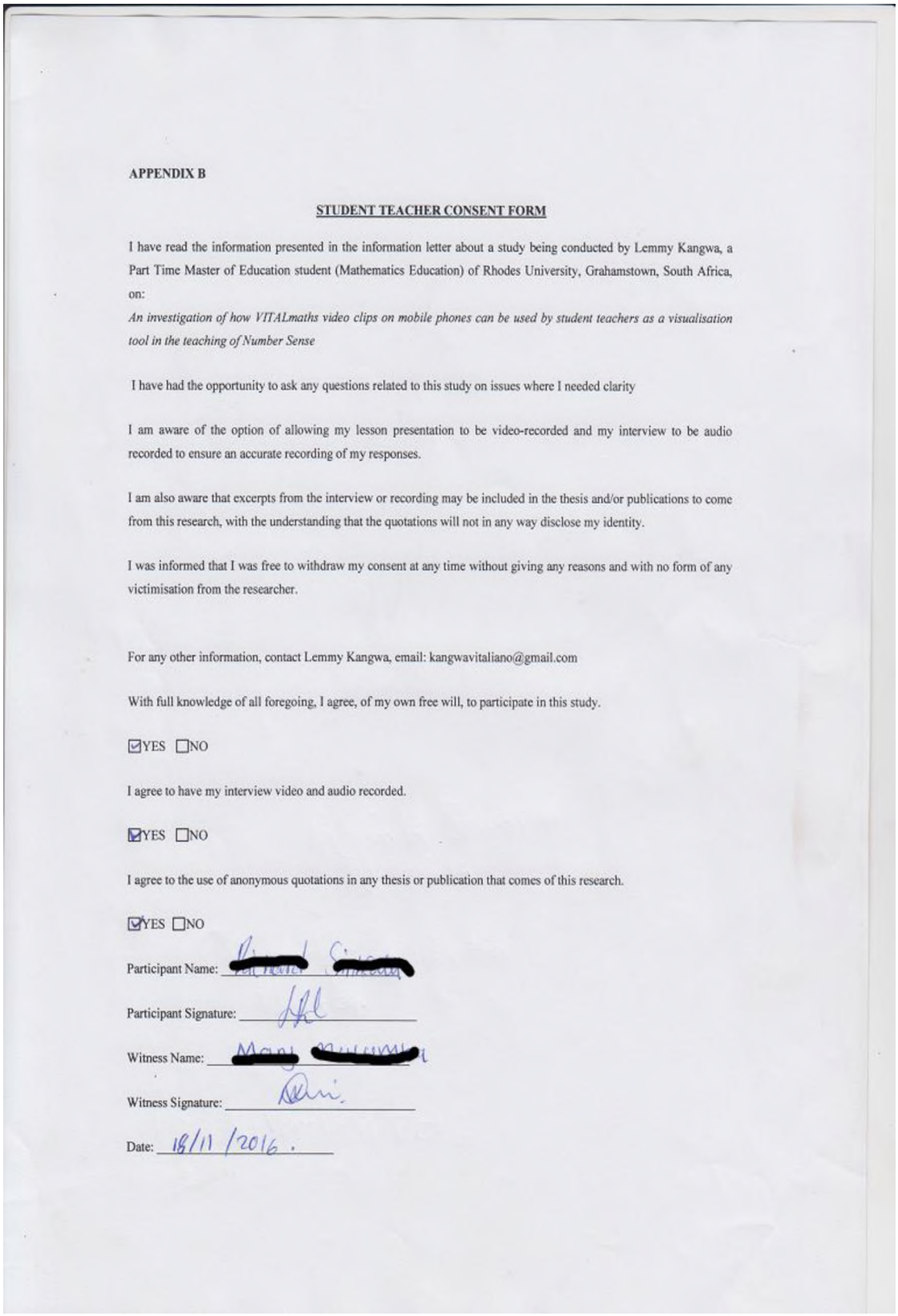
Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18th November, 2016

APPENDIX B

Student Teacher 6



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Participant Name: [redacted]

Participant Signature: [redacted]

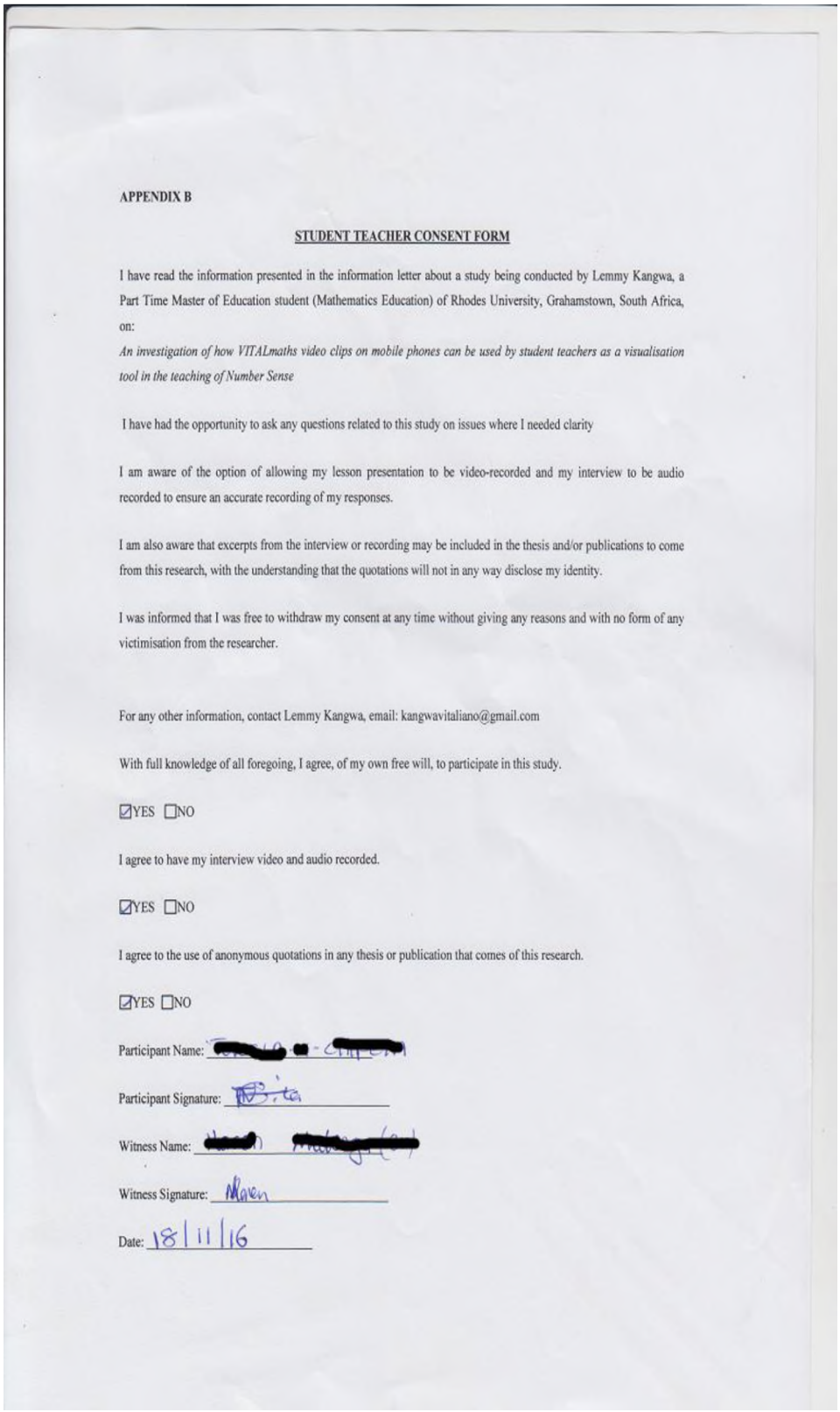
Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18/11/2016.

APPENDIX B

Student Teacher 7



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Participant Signature: [redacted]

Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18/11/16

APPENDIX B

Student Teacher 8

APPENDIX B

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Participant Name: [redacted]

Participant Signature: [redacted]

Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18th November 2016

APPENDIX B

Student Teacher 9

APPENDIX B

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Participant Signature: [redacted]

Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18/11/2016

APPENDIX B

Student Teacher 10

APPENDIX B

STUDENT TEACHER CONSENT FORM

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Participant Name: [redacted]

Participant Signature: [redacted]

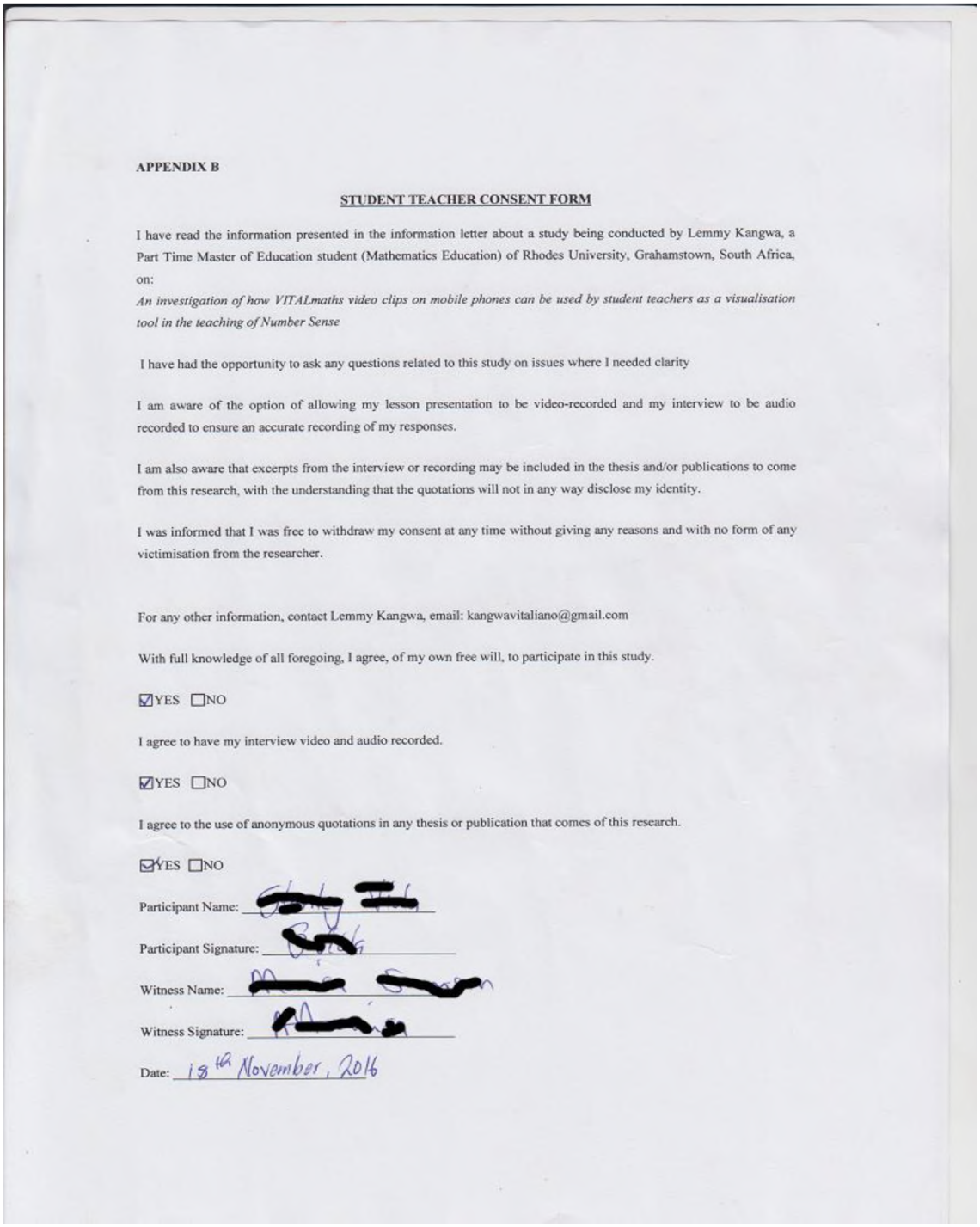
Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18th November 2016

APPENDIX B

Student Teacher 11



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Participant Name: [redacted]

Participant Signature: [redacted]

Witness Name: [redacted]

Witness Signature: [redacted]

Date: 18th November, 2016

APPENDIX C: INTRODUCTORY AND REQUEST LETTER

RHODES UNIVERSITY
Where leaders learn

12 November 2015

To whom it may concern

RE: INTRODUCTORY LETTER – LEMMY KANGWA

Mr. Lemmy Kangwa, a lecturer at Chalimbana University in Zambia, is a part-time M Ed student of Rhodes University, of South Africa. He is pursuing a research study on how Visual Technology of Autonomous Learning of Mathematics (VITALmaths) video clips on mobile phones can be used by student teachers as a visualisation tool in the teaching of Number Sense.

He would like to use your institution as a research site with Grade 7 classes. I would greatly appreciate it if you could grant him permission to go ahead.
I assure you that as part of ethics of educational research, the names of the participants and the school will be kept confidential as at no time will the researcher divulge this information without your prior consent.
Thanking you in anticipation.

Yours Faithfully

Professor Marc Schäfer PhD
Mathematics Education Chair and supervisor

APPENDIX D: INTERVIEW QUESTIONS FOR STUDENT TEACTHERS

1. Have you ever heard of the term visualisation?
2. What do you think is the meaning of Visualisation?
3. Can you give an example of when you visualise something?
4. If ask you are asked to visualise a number, what do you see? What do you visualise?
5. If ask you are asked to visualise a Mathematics teacher, what do you see? What do you visualise in your mind?
6. What do you understand by visualisation in Mathematics?
7. From a Mathematical perspective, what do you understand by number sense?
8. Why are numbers important in real life?
9. Why are numbers important in Mathematics?
10. How do you think we should teach number?
11. What are your views about presenting a lesson with the help of a video?
12. How did the aspect of visualisation enhance the presentation of information on the video clips?
13. How relevant do you find the video clips were to grade seven learners?
14. Based on the Grade 7 lesson you presented, what do you think was advantageous and what do you think was disadvantageous about the VITAL maths video clips on mobile phones?
15. So in which way do you think the video clips contributed to visualisation in your teaching?
16. How would you describe the nature of pupils' participation in your lesson when using the mobile phone?
17. So when teaching using video clips on mobile phones, what teaching strategies are important and appropriate to consider?
18. So over all what is your comment about the experience of using VITALmaths video clips and mobile phones in the classroom? What do you think should be done to make VITALmaths video clips on mobile phones to be more effective to promote conceptual understanding of a lesson in a Grade 7 class?
19. Do you think that teachers should be encouraged to use mobile phones in their teaching?
20. What is the topic of the video clip of the lesson you taught? Based on the video clip of the lesson that you taught, explain what the lesson was all about?

(Included in Focus Group Discussion)

21. (a). Based on the video clip that you used during your lesson presentation, as a group explain from a Mathematical perspective what the lesson was all about]

(b). How was the aspect of visualisation incorporated in the lesson?

APPENDIX E: LEARNERS WAITING TO AND DOING ICT EXAMINATIONS AT NIGHT