AN INVESTIGATION INTO HOW CELL PHONES CAN BE USED IN THE TEACHING OF MATHEMATICS USING *VITALmaths* VIDEO CLIPS: A CASE STUDY OF 2 SCHOOLS IN GRAHAMSTOWN, SOUTH AFRICA.

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Gerhard Ndafenongo

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ABSTRACT

Cell phones have become a ubiquitous part of daily life for both teachers and learners alike. The educational potential afforded by cell phones is diverse. The challenge for teachers is to capitalise on this ubiquity and make use of cell phones for educational purposes. This study investigates how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips. Five VITALmaths video clips were uploaded onto cell phones which were used in the classroom to explore the Theorem of Pythagoras in a visually appealing way that supported a conceptual understanding of the basis of the theorem.

The study was conducted in two high schools in Grahamstown, South Africa. It involved two teachers from each school and a total number of 47 Grade 10 Mathematics students. The participating teachers were chosen from a group of Mathematics teachers taking part in the Mathematics Teacher Enrichment Programme (MTEP) of the FirstRand Foundation Mathematics Education Chair hosted by Rhodes University. This study is framed as a case study and is grounded within the interpretive paradigm. The study captures teachers' and learners' experiences in using cell phones as instructional aids within the pedagogical context of the classroom.

This research suggests that cell phones can be a useful resource to support teaching and learning in the classroom, particularly in under-resourced schools. The use of VITALmaths video clips as mathematical content, and cell phones as a vehicle of delivery, enhanced active participation and concentration, sped up lessons, encouraged collaboration as well as interaction and hands-on exploration, and promoted both student autonomy as well as teacher enrichment.

DECLARATION OF ORIGINALITY

I, Gerhard Ndafenongo, student number g09n6060, hereby declare that this thesis is my own work, composed in my own words and is the product of my own original research. It has not been submitted in any form for another qualification or any assessment to another University or institution. Ideas, techniques, quotations, or any other material derived from the work of other people included in my thesis, published or otherwise, has been fully acknowledged in accordance with Rhodes University, Education Department reference guide.

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DEDICATION

I dedicate this thesis to my late sister Teopolina Ndafenongo, who passed away on the 7th September 2011. Before her untimely departure she stood in for me to take care of my household needs, while I was pursuing this study fulltime at Rhodes University.

ACRONYMS USED IN THIS STUDY

AMESA	Association for Mathematics Education of South Africa
B.Ed. (Honours)	Bachelor of Education (Honours)
DBE	Department of Basic Education
DFGI/P4	Deep Focus Group Interview, Pupil 4 (*for example*)
DoE	Department of Education
EC	Eastern Cape
EFGI/P2	Edge Focus Group Interview, Pupil 2 (*for example*)
FET	Further Education and Training
FHNW	University of Applied Sciences Northwestern Switzerland
FRF	FirstRand Foundation
GET	General Education and Training
ICT	Information and Communication Technology
MMS	Multimedia Message Service
MP3	An audio file which could be music or any other audio recording
MTEP	Mathematics Teacher Enrichment Programme
MXit	A Free online mobile instant messenger for social networking
NEPAD	New Partnership for Africa Development
NGOs	Non-Governmental Organisations
OBE	Outcomes-Based Education
OLPC	One Laptop Per Child
PC	Personal Computer
PDA	Personal Digital Assistant
SD card	Solar Digital memory card
SMS	Short Message Service
VITALmaths	Visual Technology for the Autonomous Learning of Mathematics
ZPD	Zone of Proximal Development

The terms *learner* and *student* are used interchangeably throughout the thesis.

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CHAPTER 1

INTRODUCTION OF THE STUDY

> *One and a half billion people, all over the world, are walking around with powerful computers in their pockets and purses. The fact is that they often do not realise it, because they call it something else.*
>
> (Prensky, 2005, p. 1)

1.1. INTRODUCTION

This chapter introduces the research study, an investigation into how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips. The chapter begins by positioning the context and landscape of the study. This is followed by a brief description of the research site and methodology, as well as a summary of the research goals. The chapter closes with an overview of the structure of the thesis.

1.2. CONTEXT/LANDSCAPE

The White Paper on e-education (Department of Education, 2004) acknowledges the magnitude of the task of delivering Information and Communication Technology (ICT) to all schools in South Africa. Nonetheless, it proposes that by 2013 all schools, teachers and students should be confident and competent users of ICT, and that ICT should be integrated into teaching and learning at all schools in South Africa. In the document *Managing ICTs in South African schools: A guide for school principals* (SAIDE, 2005), there is a serious push on narrowing the digital divide. This means that not only should ICT resources be provided to those presently lacking such resources, but the competencies required to meaningfully use and manage such resources also need to be developed. A crucially problematic issue in this regard is that the introduction and implementation of ICT resources in schools is both costly and time-consuming.

For example, in 2009 the NEIMS (National Education Infrastructure Management System) reported that of the 24 460 public schools in South Africa, only 5 714 (23%) have computer centres of some description, while only 2 449 (10%) have computer centres that are stocked, functional, and can be used for teaching and learning. This situation exists despite vigorous collaborative efforts by government, the private

sector, NGOs and communities to provide ICTs to schools in South Africa. By way of contrast, the same NEIMS report (DBE, 2009) reports that 22 479 out of the total 24 460 public schools in South Africa have cell phone network availability. Below is a table showing the Department of Education (DoE) Communication System Facility Grid.

Table 1: Ordinary School Communication System Facility Grid (Taken from NEIMS report (DBE, 2009))

Province	No of sites	Communication System Available						
		Cell phone	Telephone	Fax	2WayRadio	Internet	Callbox	No communication system
Eastern Cape	5 430	5 430	1 234	799	13	218	630	96
Free State	1 643	1 541	918	842	25	240	509	35
Gauteng	1 994	1 545	1 794	1724	139	759	1 335	25
Kwazulu Natal	5 835	5 420	2 599	1 751	36	319	869	150
Limpopo	3 918	3 846	994	523	3	77	185	46
Mpumalanga	1 540	1 455	821	599	3	25	93	19
North West	1 740	1 666	783	543	2	765	225	26
Northern Cape	609	554	452	420	14	185	219	4
Western Cape	1 466	1 022	1 421	1 350	67	1 262	764	8
Total	**24 460**	**22 479**	**11 016**	**8 551**	**302**	**3 161**	**4 829**	**409**
		One site could have more than one type of communication system						

The table above illustrates that almost 92% of South Africa's public schools are covered by cell phone communication systems compared to only 12.9% which have internet connectivity. Furthermore, Oyodemi (2009) found that in South Africa mobile signals reach 99.97% of the population, and roughly 87% of the inhabitants have cell phone subscriptions. Moreover, a recent study (ict Development Associates ltd, 2011, p. 3) reported that there are 46.4 million mobile telephones in use in South Africa's population of 47.9 million (STATSSA, 2007).

Considering the furious growth of mobile phones in society, and network support in place, it appears viable to explore Selanikio's (2008) suggestion that the use of mobile technology, specifically cell phones, may be a solution to the problem of slow

and expensive ICT rollout. Selanikio (2008) makes the pertinent remark that,"…for the majority of the world's population, and for the foreseeable future, the cell phone is the computer" (p. 2). Compared with conventional laptops (notebooks) and desktop computers, cell phones are a convenient, versatile and affordable alternative – an alternative that most students and teachers already have in their possession. The mobile phone market is evolving at an incredible rate, and this has resulted in an increase in power, functionality and affordability of cell phones (Shuler, 2009, p. 6). Most students now have their own cell phone, or at the very least have access to one. Thus, as Pursell (2009) argues, the challenge for educators is "…to capitalize on the pervasive use of cell phones by younger students for educational purposes" (p. 1219).

Mobile technology has a significant potential to alter the nature of teaching and learning (Garrison & Anderson, 2003; Prensky, 2005; Kolb, 2008). This is particularly true for low income settings (Shuler, 2009, p. 2). Ramos, Trinona and Lambert (2006) observed that "with dropping prices and increasing functionality, it is virtually certain that not too far into the future, all students will have a cell-phone" (p. 68). Even in under-resourced institutions the possibility is high for a one-to-one student-to-ICT device ratio considering the current growth of mobile phones. Such a high student-to-ICT device ratio is far less likely to be possible with conventional computers, particularly in most township or rural schools (Roschelle, Patton & Tatar, 2007, p. 5). Furthermore, Prince (2007) conducted a study on the implementation of ICT in a number of schools in the Eastern Cape which revealed that:

> …the previously disadvantaged (PD) schools were not utilizing their computers effectively. This is due to a number of factors, including a lack of funds to maintain the computers; unskilled or under skilled teachers in ICT; and under resourced computer facilities. (p. i)

Therefore, mobile learning becomes advantageous in such situations as students can carry their cell phones with them throughout the school day and at home. Furthermore, "mobile phones only require basic literacy and are therefore accessible to a large segment of the population" (Rashid & Elder, 2009, p. 1).

In addition, Jones, Issroff and Scanlon (2007) posit that affective factors play a strong role in harnessing technology for learning and list six reasons why users find mobile devices particularly engaging: control over goals, ownership, fun, communication, learning in-context and continuity between contexts (p. 18). Naismith and Corlett

(2006), in their reflections on the successes of mobile learning, identify the motivational benefit of mobile learning inside and outside the classroom as well as high levels of engagement in learning activities and learners' environments. Peters (2006) identifies a number of 'unique educational affordances' of mobile devices, such as portability, social interactivity, context sensitivity, connectivity and individuality, which can all be seen as being linked to intrinsic motivation for learners and their teachers (pp. 3-4). These characteristics and research findings all suggest that educators should explore the potentials of mobile learning to capture the attention of today's students, and to encourage active participation.

This was one of the opportunities taken up by the VITALmaths project (Linneweber-Lammerskitten, Schäfer & Samson, 2011). VITALmaths (Visual Technology for the Autonomous Learning of Mathematics) is a collaborative project between Switzerland and South Africa which designs and disseminates short mathematical video clips that are able to be viewed on a cell phone. A number of projects within South Africa have already harnessed the ubiquity of cell phone technology to support the learning of mathematics: *ImfundoYami/ImfundoYethu* (Vosloo, 2009), *M4Girls* (Vosloo, 2008), *MOBI*^{TM} (Botha, 2007; Vosloo, 2007) and *Dr Math* (Vosloo & Botha, 2009). The VITALmaths project adds to this growing endeavor of utilizing cell phone technology to support the teaching and learning of mathematics.

This particular research project investigates how cell phones and VITALmaths video clips can be used to support the teaching of Mathematics. Therefore, this study is positioned within the realm of mobile learning, *i.e. "*learning mediated through mobile technologies" (Mitchell, Cisic & Maxl, 2007, p. 6; Quinn, 2000), and uses cell phones pre-loaded with video clips designed and produced by the VITALmaths project. In particular, this study makes use of five different VITALmaths video clips on the Theorem of Pythagoras in order to investigate how cell phone technology can be used in the teaching of mathematics. The decision to use the Theorem of Pythagoras was multifaceted. Firstly, five different VITALmaths clips were available that related to this particular topic. In addition, the Theorem of Pythagoras lends itself well to both algebraic and geometric treatments, and can thus be explored in both an abstract and practical/visual manner. Furthermore, the study of Pythagoras' Theorem is an integral component across both the GET and FET phases of the South African

Mathematics curriculum (Department of Education, 2002; Department of Education, 2003).

VITALmaths video clips can be used as teaching aids, for example as motivational or explanatory tools, but they by no means replace the classroom teacher. The teacher still has an important role to play in terms of support and guidance. As Piaget (1948) remarks:

> It is obvious that the teacher as an organizer remains indispensable in order to create the situation and construct initial devices which present useful problems to the child. Secondly, he is needed to provide counter examples that compel reflection and reconsideration of over-hasty solutions. (p. 16)

Not only is the teacher central to the classroom learning experience, but there is a necessity that teachers adapt to changing contexts, changing learners, and changing learning styles. As Prensky (2001) argues, "…today's teachers have to learn to communicate in the language and style of their students…. going faster, less step-by-step, more in parallel, with more random access" (p. 4). By "language", Prensky is also referring to "technology", particularly in relation to "those younger students whose social networking concerns match their obsession with mobile technology" (James, 2011, p. 182). Prensky coined the terms "digital natives" and "digital immigrants" to describe the differences between a younger generation that has grown up with digital technologies and older generations that have learned to use those technologies as adults.

This study embraces a social constructivist theory of learning. In particular, three elements of social constructivism that are important to this study are (1) learning seen as an active process (Von Glasersfeld, 1983, 1989), (2) interaction and collaboration (Palincsar, 1998), and (3) the notion of exploration (Cobb, Yackel & Wood, 1991). The VITALmaths video clips have the potential to mediate these three important aspects of learning since these video clips are designed to support and encourage genuine mathematical exploration (Linneweber-Lammerskitten, Schäfer & Samson, 2010). Furthermore, "mobile learning facilitates both individual and collaborative learning experiences" (Attewell, 2005, p. 2). These remarks echo the social constructivist view of learning seen as an active process. In this study it is envisaged that students with different skills and backgrounds (both in terms of mobile technology and mathematics) will collaborate in activities and discussions in order to arrive at a shared understanding of the Theorem of Pythagoras. This interaction will

be mediated by the use of mobile technology, especially the potential for active participation that mobile technology brings with it (Prensky, 2008).

1.3. RESEARCH GOALS

This study seeks to explore teachers' and learners' experiences in the use of short mathematical video clips that can be viewed using mobile technology (i.e. cell phones). The central research question that frames the study is:

- How can cell phones be used in the teaching of Mathematics using VITALmaths video clips?

During the study special attention was given to the role of the teacher. It is the teacher who plans, sequences and influences the proceedings in the classroom. In social constructivism the role of the teacher goes beyond facilitation.

1.4. RESEARCH DESIGN

This study is framed as a case study and is positioned within the interpretive paradigm (Babbie & Mouton, 2001). The study aims to capture teachers' and learners' experiences using cell phones as instructional aids in the classroom. The central goal of this qualitative study is to "describe and understand, rather than explain, human behaviour" (Babbie & Mouton, 2001, p. 270).

The study was conducted in two high schools in Grahamstown, South Africa. It involved two teachers from each school and a total number of 47 Grade 10 Mathematics students. The selection of participants, or sampling, was "purposive" (Cohen, Manion & Morrison, 2007, p. 114). Teachers were chosen from participants in the Mathematics Teacher Enrichment Programme (MTEP) of the FirstRand Foundation Mathematics Education Chair hosted by Rhodes University. Grade 10 learners were selected on the basis of their familiarity with the Theorem of Pythagoras. Furthermore, it was thought that Grade 10 students would be mature enough to meaningfully engage with and articulate their experiences.

1.5. RESEARCH PROCESS

The data generation took place in three phases. This was necessary to enhance validity and reliability, as well as for triangulation through the incorporation of a variety of data collection techniques and methods, i.e. workshops with teachers, orientation lessons, observation, focus group discussions with the learners, and individual interviews with the two teachers.

The main aim of the first phase was to orientate and familiarize participants with ideas of VITALmaths, as well as with the equipment and settings of the main study. In the second phase, each teacher taught 3 lessons on the Theorem of Pythagoras, incorporating into the lesson sequence the five VITALmaths video clips relevant to the topic. All six lessons were video recorded and analysed through repeated viewings (Simpson & Tuson, 2003). The third phase incorporated interviews with the two teachers taking part in the study and, separately, with six randomly selected Grade 10 learners from each of the two classes. The main purpose of this phase was to "triangulate" and complement information gathered from phase 2.

1.6. OVERVIEW OF THESIS

This section provides a brief overview of following chapters in the thesis.

Chapter two provides an in-depth contextual background to the study. The position of cell phones within the broader field of Information and Communication Technology (ICT) is located. In addition, mobile technology and mobile learning is interrogated by scrutinising the opportunity for learning with handheld devices. Thereafter a brief synopsis of the Visual Technology for the Autonomous Learning of Mathematics (VITALmaths) project is provided.

Chapter three reviews the literature to provide a theoretical backdrop to the study. In an effort to gain insights into the learning affordances potentially offered by mobile technology, the following aspects are explored: constructivism (specifically social constructivism), active learning, interaction, and collaboration. In addition, visualization and autonomy are also discussed as important aspects of this study.

Chapter four outlines and reports on the methodology used in this research study. The structure of the chapter encompasses research goals, research orientation, sampling, data generation, data analysis, as well as issues pertaining to ethics and validity.

Chapter five takes a comprehensive look at the research results. The chapter begins by describing the context of each of the two chosen schools along with a description of the current school policy as it relates to cell phone usage. The five VITALmaths video clips are then described, as are each of each of the classroom lessons. During the course of the data analysis (interviews, focus group interviews, video footage from recorded lessons) various themes began to emerge. The chapter concludes with a discussion of each of these emerging themes: participation and engagement; collaboration; autonomy; speeding up of lessons; affective aspects; dynamic visualization; language issues; hands-on activities; and teacher enrichment.

Chapter six presents a summary of the findings along with remarks pertaining to the significance of the study as well as the limitations of the study. The chapter concludes with some recommendations for further research.

CHAPTER 2

CONTEXTUAL BACKGROUND & LITERATURE REVIEW

Could it be that mobile phones offer developing country governments a better learning tool and more educational benefits than computers?
(Vota, 2009)

2.1. INTRODUCTION

The purpose of this chapter is to provide a contextual background to the study. Firstly, the relevance and importance of Information and Communication Technology (ICT) is discussed. This leads into a discussion of the cell phone as a cheap alternative to more conventional forms of ICT within the educational arena. Thirdly, mobile technology and mobile learning are discussed with specific reference to the learning opportunities made available by mobile phones. Finally, a brief synopsis of the VITALmaths project is outlined[1].

2.2. INFORMATION AND COMMUNICATION TECHNOLOGY

The benefits of integrating Information and Communication Technology (ICT) into education are integral to the changes taking place around us. ICT is celebrated to "increase efficiency, provide access to new markets or services, create new opportunities for income generation and improving governance and give poor people a voice" (African Partnership Forum, 2008, p. 2). The emergence of ICTs thus has serious implications for the nature and purpose of educational institutions. However, ICT integration in education has varied connotations for different implementers. Therefore, for this research ICT is used in its broader definition comparable to what is outlined in the South African White Paper on e-Education (Department of Education, 2004) where "ICT" is defined as "the combination of networks, hardware and software as well as the means of communication, collaboration and engagement that enable the processing, management and exchange of data, information and knowledge" (p.

[1] The VITALmaths project produced the short video clips used in this study.

15). The most significant benefit of ICT advocated in the e-Education White Paper is that it can enhance the quality of the teaching and learning.

Furthermore, in South Africa, the White Paper on e-Education (Department of Education, 2004) clarifies that "ICTs can advance higher order thinking skills such as comprehension, reasoning, problem-solving and creative thinking" (p. 14). Imison and Taylor (2001) add that "information and communication technology (ICT) is an increasingly powerful means to enhance our abilities to think, to learn, to communicate and to use our brains creatively and logically" (p. 1). Moreover, Tinio (2003) asserts that "when used appropriately, different ICTs are said to help expand access to education, strengthen the relevance of education to the increasingly digital workplace, and raise educational quality by, among others, helping make teaching and learning into an engaging, active process connected to real life" (p. 3). Furthermore, ICTs can be seen as important "motivational tool and enhance productivity" (Department of Education, 2004, p. 14). Nangue (2011, p. 1) states that "the focus today is no longer on whether technology should be integrated into the school setting, but on *how* [emphasis added] this integration should be done to benefit all parties in a typical school setting."

In response to the worldwide demand for more ICTs in education, the South African government engraved clear and ambitious ICT policy goals in the e-Education White Paper. In particular, by 2013 all schools, teachers and students in General (GET) and Further Education & Training (FET) bands should be confident and competent users of ICT, and that ICT should be integrated into teaching and learning at all schools (Department of Education, 2004). However, Farrell and Shafika (2007) on their survey of ICT and education in Africa reports that of the 25 582 public schools in South Africa, 13 011 have one or more computers for administrative purposes, while only 5 778 have computers that are used for teaching and learning.

This situation exists despite the vigorous collaborative efforts by government, the private sector, NGOs and communities to provide ICTs to schools in South Africa. Thus, we need to be mindful that in general ICT implementation is a slow process that occurs over a period of time and in stages (Van Melle, Cimellaro & Shulha, 2003). Table 2 below provides a detailed breakdown of delivery of computers, access and use per province in South Africa.

Table 2: Computers Penetration in South African Schools (Taken from Farrell & Shatika, 2007)

Province	Total number of schools	% Schools with computers*	%Schools with computers for teaching and learning*
Eastern Cape	6 239	23.0	7.8
Free State	1 842	77.3	25.9
Gauteng	1 897	94.5	78.8
Kwazulu Natal	5 653	43.6	12.0
Mpumulanga	1 863	52.9	16.3
Northern Cape	422	91.0	60.4
Limpopo	4 187	41.8	8.7
North West	2 025	67.6	29.7
Western Cape	1 454	97.0	76.6
National	25 582	50.9	22.6
*Percentage figures have been rounded to the nearest decimal point			

The above table indicates that by 2007 only 22.6% of schools in South Africa were equipped with computers for teaching and learning. But the distribution across the provinces is very uneven. For example, the table indicates that in the Eastern Cape (EC), while 23.0% of schools had at least one computer, only 7.8% of schools had computers that were used for teaching and learning. This might well be attributed to the fact that the EC constitutes vast rural areas where the remoteness of schools is likely to adversely affect service delivery[2].

A more recent report (DBE, 2009, p. 34), indicates that there are 5 714 public schools in South Africa with a computer centre, constituting 23% of all public schools. However, of these schools, less than half (2 449) had computer (e-learning) centres that were adequately equipped, i.e. with an adequate number of computers and other technologies for classroom teaching and learning[3].

These figures highlight one of the critical drivers of this study - an exploration of alternative technologies that can benefit all parties in a typical school setting,

[2] In addition, it has been remarked that "the lack of computers in schools in the seven provinces could be reflective of lack of computers at home" (ict Development Associates ltd, 2011, p. 30).

[3] Farrell and Shafika (2007) reported 5 778 schools with computers, whereas the DBE (2009) gives a reduced value of 5 714 schools. This demonstrates how difficult it is to get accurate and reliable data regarding ICT facilities in schools.

particularly in rural areas (Nangue, 2011). With this in mind, the following section turns to the cell phone as an affordable alternative to more conventional forms of ICT in the educational arena.

2.3. CELL PHONES AS ICT IN EDUCATION

It is interesting and enlightening that in South Africa mobile signals reach 99.97% of the population (Oyodemi, 2009). Moreover, recent research found that South Africa had 46.4 million mobile telephones in use (ict Development Associates ltd, 2011, p. 3) in a population of 47.9 million (STATSSA, 2007). In addition, out of a total number of 24 460 public schools, 22 479 have cell phone communication systems available, while in contrast only 3 161 public schools have internet connectivity via desktops and laptops (DBE, 2009, p. 37). These figures emphasise that there is high penetration of mobile phones and network support in the country.

Therefore, it is imperative to explore cell phones as an alternative to the slow and expensive process of distributing laptops or desktops to schools[4]. It is clear that cell phones are an important component of newly emerging ICTs (Prensky, 2001; Chan, Roschelle, Hsi, Kinshuk, Sharples, Brown, et al., 2006). Compared with conventional laptops (notebooks) and desktop computers, cell phones are a convenient, versatile and affordable alternative – an alternative that most students and teachers already have in their possession (Selanikio, 2008, p. 1). This has opened up new learning opportunities and provided access to educational resources well beyond those traditionally available. Attewell (n.d.) proposes that the enthusiasm of particularly young students for mobile phones can be harnessed to encourage participation in education or training.

Of significance, Mobile Africa reports that “industries estimate that there are more than 500 million mobile phone subscribers in Africa now, up from 246 million in 2008” (Rao, 2011, p. 5). Selanikio (2008) makes the pertinent comment that “for the

[4] For example: the New Partnership for Africa's Development (NEPAD) initiative to sell “laptops to governments and issued to children by schools on a basis of one laptop per child (OLPC)” (OLPC, 2010). However, these specialized efforts have always been restrained by the massive costs to allocate and support such technology diffusion (Vota, 2009).

majority of the world's population, and for the foreseeable future, the cell phone is the computer" (p. 1). This sentiment is echoed by Ford (2009) in her pronouncement that "the cell phone is poised to become the 'PC of Africa'". Trucano (2009) adds that throughout much of the developing world, when we speak of a low-cost ICT devices used by the masses, we are speaking about phones, not computers.

To grasp the popularity of the cell phone in Africa, the graph below reflects the percentage of mobile phone subscribers as a function of the total population in the country. Countries are sorted by ranking on the UN's Humana Development Index (HDI)[5]. South Africa has one of the highest cell phone enrolment rates, in excess of 90%.

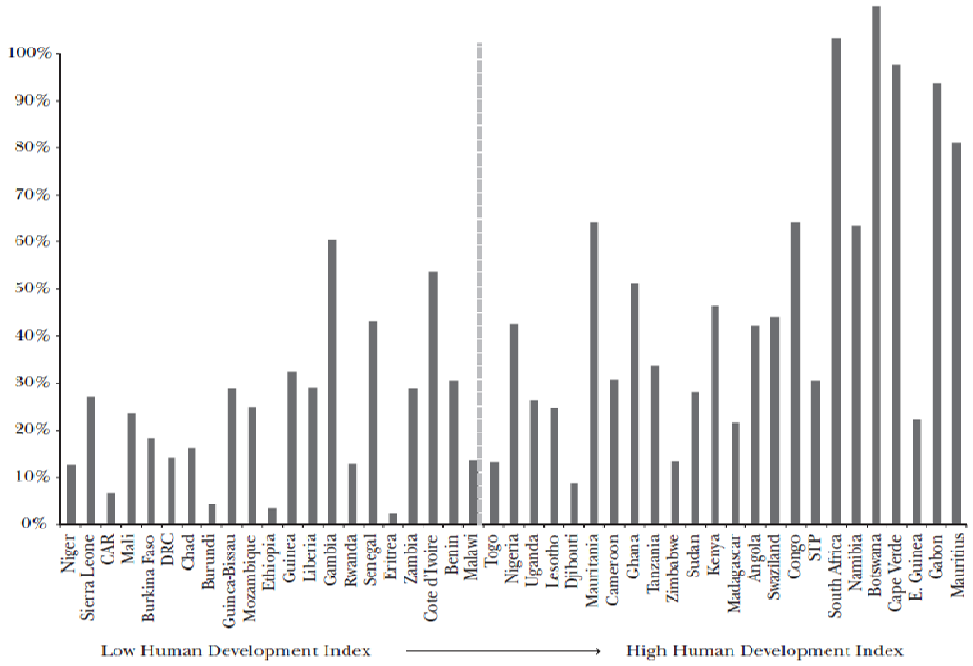


Figure 1: Number of mobile phone subscribers as a percentage of the population, 2008 (Countries arranged by Human Development Index from low to high). Adapted from Wireless Intelligence 2008, in Acker and Mbiti (2010).

[5] CAR is the Central Africa Republic, DRC is the Democratic Republic of Congo and STP is Sao Tome and Principe.

Today there is an exponential mobile phone revolution, particularly in Africa[6]. While saturation levels are already nearing one-to-one in the developed world, cell phone usage is gaining quickly in the urban areas of the developing world. Because of their relative low costs and low operating needs, it is now given that mobile phones will always outnumber computers (Rashid & Elder, 2009, p. 2; Vota, 2009). In particular, the declining costs of cell phones have made them increasingly affordable to the youth market. Kreutzer (2009) found that among a group of low income youth in Cape Town, more than 77% of the group had direct access to cell phones and internet connectivity via them. Therefore, utilizing cell phones in education is positioned to be a viable alternative to more conventional forms of ICT. The viability of this is further enhanced by considering the fact that many students and teachers already have their own cell phones, which have been personally financed, thus reducing potential cost implications.

Compared to conventional laptops and desktops, cell phone advocates argue that a cell phone is a great device as it has a relatively long battery life, is portable and is becoming more and more affordable - prices are dropping steeply and rapidly and more features are becoming available in low-end mobiles (Pensky, 2008; Trucano, 2009; Vota, 2009). Vota (2009) adds that cell phones are gaining in capacity and computing power, with high-end smart phones already rivalling some of the low-end netbooks. Furthermore, Wade (2004) reports that the mobile phone has been regarded as a more accessible and less expensive means to close the digital divide.

To most educators, ICT meant a "computer", i.e. a PC or a laptop. However, it is apparent from the literature that mobile phones, PDAs, IPods, MP3 players, etc. are newly emerging ICTs with educational potential. Additionally, these devices are currently being developed with almost the functionality of a computer[7]. With accessories such as mini SD cards, cell phones can store huge amounts of information. Therefore, “it is time to begin thinking of our cell phones as computers—even more powerful in some ways than their bigger cousins” (Prensky, 2005, p. 1).

[6] The terms cell phone, cellular telephone, and mobile phone are used synonymously throughout the text.

[7] This functionality includes: typing notes, calculator, internet, sending & receiving emails, plus camera, radio, mp3 player etc.

It is evident from the literature that ownership of mobile phones by young students is likely to exceed that of desk-based computers. The possibility is thus foreseeable that "networked handhelds can allow a 1:1 student:device ratio for the first time, enabling ready-at-hand access to technology throughout the school day and throughout the learner's personal life" (Roschelle et al., 2007, p. 1). In such an ideal scenario cell phones become advantageous over conventional laptops and desktops that are installed in a computer room or laboratory where learners only have access once a day or sometimes once a week.

In the literature review as well as in discussion with a number of people about using mobile technology in education, I found two major views regarding the use of mobile phones in education. These I classify as the *optimistic* and *pessimistic* views.

Optimists see cell phones as an important consideration in the educational arena and as such focus on the positive aspects of mobile technology as an aid to teaching and learning. Firstly, cell phones work using the radio spectrum. As such, there is no need to rely on physical infrastructure such as roads and phone wires, and base-stations can be powered using their own generators in places where there is no electrical grid (Economist, 2008). Mobile phones might therefore be particularly useful tools in rural areas where communities and/or schools are not yet connected to the municipal grid. In addition, "it has come to light that new solar-powered cell phones have been recently introduced in the market" (Acker & Mbiti, 2010, p. 229). Secondly, "mobile phones only require basic literacy and are therefore accessible to a large segment of the population" (Rashid & Elder, 2009, p. 1). Thirdly, the latest models, and particularly those coming onto the market in the 3rd Generation wave of technology, offer access to a diverse mix of broadcast and entertainment media, including photography, video, radio and music, games, Internet browsing and personal software applications, including SMS, MMS and video messaging, chat, contact, dating and context of imagery, status and fashion. These very features and facilities make mobile phones particularly attractive to young users (Childnet International, 2004). Fourthly, beyond basic connectivity, mobile phones offer benefits such as mobility and security to owners (Donner, 2006). Finally, cell phones are positioned to be viable in improving educational efficiency and access to information anytime anywhere as the device is always on. This makes it easier for students to access the world's knowledge systems and be alerted to changes or other news any

time with a view to preparing them for the acquisition of future employable skills as well as current needs of the labour market (Swarts, Clarke, Hooker, Palmer & Wachira, 2011).

In contrast, the *pessimists*' view is that there are numerous limitations to using mobile phones in education when compared with computers. Trucano (2009) summarised these into five basic limitations:

1) Small screen;
2) Limited battery life;
3) Difficulties with input;
4) The potential for distraction during lessons;
5) An almost cynical refusal to embrace a new technology and recognise its potential.

Pachler, Cook and Bachmair (2010) echo a number of these limitations and highlight the following disadvantages of using mobile devices: small screen, possibly not robust enough for schools, lack of technical support, data loss due to battery problems, problems with linking to networks.

The biggest challenge at the moment is that teachers are reluctant to use mobile phones in the classroom particularly in view of some of the limitations described above. In addition, the tension is that currently "most schools and colleges do not recognise informal networked interaction as legitimate learning and they forbid children to bring phones and personal computers into the classroom" (Sharples, 2007, p. 23).

The views of pessimists are worth taking note of. However, the position of this study is to explore the much advocated possibility of using mobiles as an instructional aid[8]. With this in mind, the next section interrogates the educational affordances made available by mobile technology and mobile learning.

2.4. MOBILE TECHNOLOGY AND MOBILE LEARNING

There are a number of reasons to suggest that mobile learning has an important place in the educational arena. Firstly, the exponential growth of mobile technology in recent years, the increasing availability of high-bandwidth network infrastructures,

[8] Some of the disadvantages noted have already diminished in the recent years (Kinshuk & Patel, 2003; Ramos et al., 2006).

advances in wireless technologies, and the popularity of handheld devices have opened up new accessibility opportunities for education (Kinshuk, 2003). Secondly, there is the growing size and frequency of dedicated conferences, seminars and workshops on mobile learning internationally (Traxler, 2005). Thirdly, there is potential for South Africa, considering that the penetration of mobile technology is extremely high in the country (ict Develoment Asociates ltd, 2011, p. 30). Lastly, mobile technology evolution is visible to every person, and the impact on human behaviours, communication and learning is therefore noticeable.

Mobile technologies today are pervasive as a new 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). Mobile technology in broader terms includes all mobile devices that fall into a series of categories: PDAs/smart phones, digital phones and non-telephony devices including MP3 players. Mobile technology thus includes any device that is “small, autonomous and unobtrusive enough to accompany people in every moment in their every-day life, and that can be used for some form of learning” (Kineo and UFI/Learndirect, 2009, p. 4).

Mobile devices support and facilitate the newly emerging mobile learning (also known as m-learning), an advent born out of innovation around e-learning. To be explicit, the relationship between mobile technology and mobile learning is such that mobile technology (devices) retrieves information from other sources and carries that mobile content in a type formatted for mobile phones. When this content is purposefully accessed or viewed or even accidentally consumed then mobile technology acts as a potential agent for flexible mobile learning. As a result of mobile learning being an emerging approach to learning, “there is a need to re-conceptualise learning for the mobile age, to recognise the essential role of mobility and communication in the process of learning” (Sharples, Taylor & Vavoula, 2005, p. 1).

Many researchers have defined the term “mobile learning” and its content from various points of view:

- According to Kaplan-Leiserson (2005) mobile learning is “the new possibilities that are available to people given the mass deployment of devices that

everyone now has in their hands and the new connectivity that is coming" (p. 1).

- Mobile learning can be defined as "... any service or facility that supplies a learner with general electronic information and educational content that aids in acquisition of knowledge regardless of location and time" (Lehner & Nosekabel, 2002, p. 103).
- Mobile learning can also perhaps be defined as "any educational provision where the sole or dominant technologies are handheld or palmtop devices" (Traxler, 2005, p. 262). This definition may mean that mobile learning could include mobile phones, smartphones, personal digital assistants (PDAs) and their peripherals, perhaps tablet PCs and laptop PCs, but not desktops in carts and other similar solutions.

With full consideration of the above definitions and many others in the field, mobile learning in this study is simply perceived as "learning that takes place with the help of mobile devices" (Quinn, 2000) – in this case the cell phone.

Due to the high penetration and pervasiveness of mobile phones in South Africa (ict Develoment Asociates ltd, 2011, p. 30), a number of projects have been piloted in recent years to capitalise on the ubiquity of cell phone technology in the society to support learning. Most projects in general made use of the popular MXit platform (an instant messaging social network platform) in an endeavour to encourage learners to utilize it for education purposes. A number of projects focused specifically on mathematics education, and these are briefly described below:

- *ImfundoYami/ImfundoYethu* is a mobile learning platform that delivers mathematics education to Grade 10 learners through MXit. Mathematics teachers log into a web-based management system from which they can distribute exercises to the learners, provide personal support and monitor both results and learners' activity (Vosloo, 2009).
- The *M4Girls* projects aims to improve the mathematics performance of Grade 10 female learners in rural schools in South Africa. Learners are provided with cell phones containing a number of mini videos (2-3 minutes in length), mobile episode animations, and games (Vosloo, 2008).
- MOBI^{TM} is a proprietary product that can be accessed through most java-enabled cell phones. The product provides the user (Grade 10 to 12 learners) with access

to tutorials in the form of streamed videos, past examination papers with solutions and an opportunity for learners to use closed chat rooms to form study or discussion groups (Botha, 2007; Vosloo, 2007).

- Dr Math enables learners to access assistance with their homework assignments by interacting with tutors through the MXit platform (Vosloo & Botha, 2009).

Mobile and wireless tools can be of significant assistance in achieving authentic learning goals, as they enable learners to take their learning away from school and into the world, and their experiences from outside the school with them to learn. Jones et al. (2007) posit that affective factors play a strong role in harnessing technology for learning and list six reasons why users find mobile devices particularly engaging: control over goals, ownership, fun, communication, learning in-context and continuity between contexts (p. 18). Naismith and Corlett (2006), in their reflections on the successes of mobile learning, identify the motivational benefit of mobile learning inside and outside the classroom as well as high levels of engagement in learning activities and learners' environments. Peters (2006) identifies a number of 'unique educational affordances' of mobile devices, such as portability, social interactivity, context sensitivity, connectivity and individuality, which can all be seen as linked to intrinsic motivation for learners and their teachers (pp. 3-4). Additionally, Smith, Mohan and Li (1999) outlined four promising characteristics of hand-held devices, namely:

1) Small size and high portability;
2) Instant access with no waiting for boot-up;
3) Flexibility to support a wide range of learning activities; and
4) The cost of the technology is relatively cheap.

I attempt here to delineate the affordances that mobile devices and attendant technologies can provide to teaching and learning. By its nature, mobile learning can be socio-constructivist (Hayes, Pathak, Joyce & Hall, 2005). Knowledge which is the result of learning must be actively constructed by the learner who acquires the knowledge from many different sources including other learners (Sharma & Kitchens, 2004; Hadjerrouit, 2005). Social constructivist perspectives (discussed further in Chapter 3) support this perception by treating the learner not as an isolated individual but as part of a social network, interacting with other learners and the environment. In particular, the activities used in mobile learning have the potential to embrace this

(Sprague & Dede, 1999 as cited in Hayes et al., 2005), thereby increasing motivation, promoting interactive learning, developing cognitive skills (ordering, evaluating, synthesising), and facilitating the control of the learning process and its relationship with the real world (Zurita & Nussbaum, 2004 as cited in Hayes et al., 2005). Prensky (2005) asserts that:

> there are many different kinds of learning and many processes that people use to learn, but among the most frequent, time-tested, and effective of these are listening, observing, imitating, questioning, reflecting, trying, estimating, predicting, speculating, and practicing. *All* of these learning processes can be supported through cell phones. (p. 2)

All these aspects promote mathematical exploration, another broad feature of the social-constructivist approach, because they highlight "learning as an active process of building knowledge and skills through practice" (Sharples et al., 2005, p. 3). Such perspectives make mobile learning quite different compared with traditional teacher-centred classroom learning environments. These aspects will be dealt with more thoroughly in the Theoretical Framework chapter.

In terms of the notion of mathematical exploration, the VITALmaths video clips used in this study are specifically designed and developed to "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 generalise results" (Linneweber-Lammerskitten et al., 2011, p. 355). A brief outline of the VITALmaths project is provided in the following section.

2.5. VISUAL TECHNOLOGY FOR THE AUTONOMOUS LEARNING OF MATHEMATICS (VITALmaths)

VITALmaths is collaborative research and development project between the University of Applied Sciences Northwestern Switzerland (FHNW) and Rhodes University in South Africa (Linneweber-Lammerskitten et al., 2010). The project involves the development, distribution and evaluation of short mathematical video clips which have been designed specifically to support and encourage genuine mathematical exploration and autonomous learning. It is within this project that I found, and was attracted by, interesting video clips on different mathematical concepts. The databank of video clips can be freely downloaded or streamed from a dedicated website: www.ru.ac.za/VITALmaths. Alternatively, files can be freely

downloaded to a PC then 'sideloaded' to a mobile device, so that mobile download charges are not incurred. This is an important consideration to keep in mind, especially in low income settings. Linneweber-Lammerskitten et al. (2011) explain 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).

Linneweber-Lammerskitten and Schäfer (2010) acknowledge the existence of other video technologies in the mathematics classroom, but contest that these films are often too long and are underpinned by specific outcomes and pedagogical imperatives. The VITALmaths project has thus been established to fill this void (*ibid*). VITALmaths video clips are silent, short in duration (typically 1 to 3 minutes), and are produced using a stop-go animation technique incorporating natural materials as opposed to high-tech graphics. These video clips can be viewed on cell phones as they are released in MP4 and 3G2 formats. According to Linneweber-Lammerskitten et al. (2010) "the MP4 format is suitable for PCs, iPods, iPhones and many modern cell phones, while the 3G2 format is designed specifically for use on older or more basic cell phones" (p. 33).

Specific to the South Africa context, the project is especially "interested in making use of cell phone technology as the primary distribution platform" (Linneweber-Lammerskitten et al., 2011, p. 353). This is also coupled with the ambition of taking advantage of the ever-presence of cell phones in the hands of teachers and young students. Further, it is also anticipated that this innovation will have a significant positive impact for teachers in deep rural setting where access to mathematical resources is very limited (*ibid*). Fear of other obstacles such as supply of electricity, access to e-learning labs and internet connectivity may well be bypassed with the use of cell phones. Considering, as indicated earlier, that in South Africa mobile signals reach 99.97% of the population (Oyodemi, 2009) and there were 43,317,511 active mobile phone lines reported (Wireless Intelligence, 2008 in Acker and Mbiti (2010)) for South Africa's 47,850,700 inhabitants (STATSSA, 2007), it makes good sense for the education sector to tap into the use of cell phones for educational purposes (Pursell, 2009).

For the purposes of this study, five VITALmaths video clips were chosen that adopt different visually appealing approaches to proving or engaging with the Theorem of Pythagoras in a conceptually meaningful manner. This study made use of these five VITALmaths video clips on the Theorem of Pythagoras in order to investigate how cell phone technology can be used in the teaching of mathematics in two Grade 10 classrooms.

2.6. CONCLUSION

The purpose of this chapter was to provide a contextual background to the study. Firstly, the relevance and importance of Information and Communication Technology (ICT) was discussed. This was followed by a discussion of the cell phone as a cheap alternative to more conventional forms of ICT within the educational arena. Thirdly, mobile technology and mobile learning was discussed with specific reference to the learning opportunities made available by mobile phones. Finally, a brief synopsis of the VITALmaths project was presented.

During the course of this chapter a number of theoretical issues were briefly touched on in terms of the educational affordances offered by mobile technology. An interrogation of these theoretical considerations forms the basis of the following chapter.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1. INTRODUCTION

Recent advances in mobile technologies are deeply intertwined with learning due to the full spectrum of information and entertainment options available to users. As a result of information being integral in teaching and learning, the case of mobiles as carriers of information that can be used for learning necessitates a probing of the relevant learning theories to interrogate the potential affordances offered by mobile phones to the teaching and learning experience.

The purpose of this chapter is thus to provide a theoretical backdrop to the study. In an effort to gain insights into the learning affordances potentially offered by mobile technology, the following aspects are explored: constructivism (specifically social constructivism), active learning, interaction, and collaboration. Towards the end of the chapter visualization and autonomy are also discussed as important aspects of this study.

3.2. SOCIAL CONSTRUCTIVISM

Constructivism is a theory of knowledge (epistemology) that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas (Piaget, 1967). According to the Western Cape Education Department (2000) it is understood that the essence of constructivism "…was a shift away from the idea that knowledge is given to passive learners to the idea that active learners invent knowledge as they encounter and engage with it" (p. 2). In his own words, Jean Piaget in 1948 put the matter as follows:

> The basic principle of active education methods …. may be expressed as follows; to understand is to discover, or reconstruct by discovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition. (p. 20)

It is now well accepted that according to the constructivist view of learning mathematics, students construct their own mathematical knowledge rather than receiving it in finished form from the teacher or a textbook (Perry, Goeghegan, Howe, & Owens, 1995). Naturally, mobile technology is a key feature in many activities in active life carried out by young people as they work collaboratively and share information. For example: making arrangements; passing on information; sharing jokes, graphics, or ring tones; texting each other using a still developing new language. It is this activeness, human interaction, interaction with the environment and the nature of knowledge that develops during learners' engagement with mobile technology that is particularly attractive and important in adopting mobile learning as a learning environment[9].

Social constructivism emphasizes that learning is an active social process in which individuals make meanings through the interactions with each other and with the environment they live in. "Knowledge is thus a product of humans and is socially and culturally constructed" (McMahon, 1997). Ramaley and Zia (2005) maintain that the newer forms of technologies such as mobile learning "enrich traditional forms of learning and serve as links between active and passive learning, individual and group learning, and the transmission and generation of knowledge" (p. 10). Like other proponents of constructivism, Ramaley and Zia (2005) emphasize the importance of learning environments which are active, social, and learner-centred. Furthermore, they argue that the new generation of students is experiential, engaged and constantly connected, with a strong need for immediacy.

Mobile learning proponents advocate that the activities used in mobile learning are social-constructivist since the learners work in collaborative groups (Sprague & Dede, 1999 as cited in Hayes et al., 2005), thereby increasing motivation, promoting interactive learning, developing cognitive skills (ordering, evaluating, synthesising), and facilitating the control of the learning process and its relationship with the real world (Zurita & Nussbaum, 2004 as cited in Hayes et al., 2005). According to Sharples et al. (2005) the technological layer represents learning as an engagement with technology, in which tools such as computers and mobile phones function as interactive agents in the process of coming to know. In addition, there is an

[9] This features prominently in the general principles of adopting a constructivist learning environment (Western Cape Education Department, 2000).

overwhelming claim that learning mathematics is as much about *doing* as it is about *knowing* and technology is seen to change the nature of school mathematics by engaging students in more active mathematical practices such as experimenting, investigating and problem solving that bring depth to their learning.

The Zone of Proximal Development (ZPD) of Vygotsky (1978), well known when acknowledging the importance of interactions and collaboration, centres on the idea that students, with the help from adults, teachers or peers who are more advanced, master concepts and ideas they perhaps could not understand on their own. The person, or people, offering the help are already capable of performing the activity and so are called more knowledgeable others (MKO). This foregrounds the teacher as an organizer and facilitator throughout this study.

3.3. ACTIVE LEARNING

Briefly, active learning has been described as involving students in the classroom in activities other than listening that are meaningful and make them think about what they are doing (Bonwell & Eison, 1991). Knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner. Piaget asserted that for a child to know and construct knowledge of the world the child must act on objects and it is this action which provides knowledge of those objects (Sigel & Cocking, 1977). The mind organizes reality and acts upon it. The learner must be active; he is not a vessel to be filled with facts. Knowledge is not passively received but actively built up by the cognizing subject (Von Glasersfeld, 1983, 1989).

Research has shown that students learn best when actively engaged in the learning process and these active approaches are more effective in developing students' ability for higher-order thinking tasks such as analysis, synthesis, and evaluations (Prince, 2004). This kind of thinking is required to achieve the critical outcomes stated in the National Curriculum Statement for South Africa (Department of Education, 2003). When it comes to mobile technology, Ramaley and Zia (2005) maintain that the newer forms of technologies such as mobile learning "enrich traditional forms of learning and serve as links between active and passive learning, individual and group learning, and the transmission and generation of knowledge" (p.10).

According to Schweitzer and Brown (2007) active learning takes place when the activities are interactive, simple to understand, have a short time frame, are creative and motivational, are sometimes collaborative, and relevant (p. 208). To expand on this, active learning is said to be effective when learners are engaged in a task and are receiving feedback instantly either from teachers, machine or peers. Activities should be at the level of the student and should not require a lot of explanation or deep mathematics. Creativity and motivation are other aspects that can help students to carry on attaining individual satisfaction and educational outcome rather than working for material reward. "Learning mathematics is as much about *doing* as it is about *knowing*….. Technology can change the nature of school mathematics by engaging students in more active mathematical practices such as experimenting, investigating and problem solving that bring depth to their learning" (Goos, 2010, p. 68). Olive and Makar (2010) argue that mathematical knowledge and mathematical practices are inextricably linked, and that this connection can be strengthened by the use of technologies.

3.4. INTERACTION AND COLLABORATION

Voss, Wiley and Carretero (1995) exhort that the socio-cultural revolution has focused on "learning in out-of-school contexts and on the acquisition of intellectual skills through social interaction" (p. 174). To present arguments that support interaction in learning I have drawn from both Piaget and Vygotsky, great theorists who made enormous contributions toward interaction as a critical aspect of learning. Piaget and his disciples advocated that "cognitive conflict created by social interaction is the locus at which the power driving intellectual development is generated" (Perret-Clermont, 1980, p. 12). Vygotsky (1978) asserts that "learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and with his peers" (p. 90).

In terms of collaboration, Bell, Grossen and Perret-Clermont (1985) suggest that students working collaboratively can be more successful than when working alone. Coming back to mobile technology, Prensky (2008) emphasises that "the role of technology in our classrooms is to support the "new" pedagogy of kids teaching

themselves with teacher's guidance" (p. 3). This is originally proposed by Piaget (1948) who underscores that:

> It is obvious that the teacher as an organizer remains indispensable in order to create the situation and construct initial devices which present useful problems to the child. Secondly, he is needed to provide counter examples that compel reflection and reconsideration of over-hasty solutions. (p. 16)

In addition, Colley and Stead (2004) explain that mobile devices are a key feature in many activities carried out by young people as they work collaboratively and share information. This natural collaboration is an opportunity to enhance formal learning as highlighted by Vygotsky (1978).

It is clear that an appropriate balance between creative freedom and effective guidance is crucial to the appropriate utilisation of mobile technology in the classroom context. Mobile technologies and mobile learning need to be seen as a potential means to encouraging innovative pedagogy, as well as supporting teaching and learning in addition to learners' autonomy. However, the interaction between pupil and teacher still needs to be seen as one of primary importance.

3.5. MATHEMATICAL EXPLORATION

The National Educational Standards in Switzerland (Weinert, 2010 in Linneweber-Lammerskitten et al., 2011) and the Revised National Curriculum Statement in South Africa (Department of Education, 2003) both place emphasis on mathematical exploration as an important approach for learning mathematics. The VITALmaths video clips are produced fundamentally to support and encourage genuine mathematical exploration (using natural materials that learners can source locally) by encouraging a desire to imitate, experiment, use trial-and-error, formulate conjectures and generalize results (Linneweber-Lammerskitten, et al., 2011). In this way students with weaker mathematical ability can be exposed to challenging but interesting mathematics.

However, the role of technology in the classroom is not meant to replace the teacher but rather to support the teaching process in terms of efficiency and to encourage participation. Social constructivism (Vygotsky, 1982) emphasises intrinsic learning

through social interactions such as modelling or imitation and accepts the plurality of meanings.

Mathematical exploration allows students to explore not only the structure of accessible objects in the environment, but also construct their own objects and explore the mathematical relationships between and within the objects, as well as the representations that make them accessible (Hoyles, 1993). This verification of correctness, particularly in the realm of visual proofs such as Pythagoras' Theorem, makes it easy for students to understand and generalise their experience to be able to tackle other mathematical problems. However, research suggests that

> to preserve the essence of exploratory learning environment the role of teacher should be that of a '*competent guide*[10]', a *'facilitator*[11]*'* who, apart from structuring activities and promoting the appropriate learning atmosphere, recognises the need for students' autonomy and responsibility, directs their attention accordingly, and can help them organise their environment and plan and monitor their work. (Mavrikis, Geraniou, Noss & Hoyles, 2008, p. 1)

Although the social constructivist learning theory to which this study subscribes demands for greater learner engagement and participation, the role of the teacher in making this possible remains critical. Mavrikis et al. (2008) propose that if teachers can adhere to their role as faclitators:

> ...teachers can support the processes of mathematical exploration by helping students set and monitor their goals, by directing their attention appropriately, by helping them reflect on their actions… In addition, teachers can help students reflect on their solutions and finally allow them, if not encourage them, to come up with more alternative solutions. (p. 3)

The VITALmaths project also anticipates the clips will "stimulate curiosity, motivation, a willingness to know, determination to overcome disappointment and frustration, and a willingness to try things out" (Linneweber-Lammerskitten, et al., 2010, p. 30).

[10] Leron, U. (1985) Logo today: Vision and reality. *Computing Research 12*, 26–32 (In Mavrikis et al., 2008).

[11] Hoyles, C., & Sutherland, R. (1989). *Logo Mathematics in the Classroom*. Routledge (In Mavrikis et al., 2008).

3.6. VISUALIZATION IN MATHEMATICS EDUCATION

There is an increasing recognition that visualization plays an important role in learning mathematics (Ben-Chaim, Lappan & Houang, 1989; Cobb et al., 1991; Thornton, 2001). Makina (2010) affirms that visualization is a very important cornerstone in "teaching for understanding" in mathematics because it aids the teacher with facilitation of lessons and with the ability to engage learners in realistic situations. Zimmerman and Cunningham (1991) described visualization as "the process of producing or using geometrical or graphical representations of mathematical concepts, principles or problems, whether hand drawn or computer generated" (p.1). They add that computer graphics has greatly expanded the scope and power of visualization as a mathematical tool. To cover the whole scope of visualization, one should think about other technologies such as videodiscs, film, and interactive programs. This study adds to this scope by exploring the use of cell phones as a technology in visualizing mathematics.

Furthermore, research has found that graphics and visual imagery increased the amount learned by adults (Alesandrini, 1984) and by children (Pressley, 1977). According to Arcavi (2003, p. 215) visualization offers "a method of seeing the unseen and we are encouraged and should aspire to 'see' not only what comes 'within' sight', but also what we are unable to see". Visual images make a much greater impact than printed or spoken words. People tend to forget words they hear or read, but images are retained for a long time because they have emotional as well as intellectual appeal (Apostol & Blinn, 1993). According to Makina (2010) this is because visualization incorporates those mental processes that make use of, or are characterized by, visual imagery, visual memory, visual processing, visual relationships, visual attention and visual imagination. This helps learners to construct useful mental schemata. Piaget, cited in Woolfork (1987), defined a schema as the mental representation of an associated set of perceptions, ideas, and/or action and schemata are basic building blocks of thinking.

With visualization, the overall goal of instruction is to help learners construct mental representations that correctly or accurately mirror mathematical relationships in instructional representation located outside the mind. Visualization then becomes an important aspect of mathematical understanding, insight and reasoning, which in turn enhances the students' critical thinking. As Aristotle stated, "without image, thinking is

impossible" (as cited in Benson, 1997, p. 141). Tall (1991, p. 2) adds that "exploratory stages of mathematical thinking benefit from building up an overall picture of relationships and such a picture can benefit from visualization. Like exploration, visualization sometimes helps students to make generalizations of relationships." Visualization is also "a way to understand mathematical principles in a more general form" and is a way to "motivate children to search for the cause of the truth of a principle" (Malaty, n.d., p. 2).

Visualization, both static and dynamic, has a long history of use in instructional material. However, research shows that simply adopting a new technology does not necessarily improve learning (Hegarty, 2004). Of critical importance, in terms of efficacy, is the manner in which the technology is used. It is in this context that the present study finds importance.

3.7. AUTONOMY IN MATHEMATICS EDUCATION

The VITALmaths project which produces the video clips used in this study foregrounds the importance of autonomous learning[12] (Linneweber-Lammerskitten, et al., 2010). A cell phone acts as a vehicle which provides an environment where learners navigate, explore and imitate the video clips at their own pace. Learners have full control of their own speed in watching the videos as well as trying them out and re-watching them if necessary.

Cell phones thus can promote autonomy through learner control. Since cell phones are free of the teacher, learners can take greater control over the learning, thereby promoting independence, satisfaction, and enthusiasm (Stemler, 1997). Hannafin (1984) explains that learner control is demonstrated in lessons where individuals control the path, pace and/or contingencies of instruction. He adds that one student may learn all the intended information rapidly and never need to branch off for review or remediation, while others will want to repeat or rerun a presentation. Overbaugh (1994) indicates that there is evidence from research that students in control of their instruction can achieve higher results.

[12] Within the context of social constructivism, autonomous learning is not necessarily restricted to an individual learner making decisions in isolation.

As highlighted earlier, the VITALmaths project perpetuates and encourages autonomous learning through the video clips. Linneweber-Lammerskitten et al. (2010) reiterate a social constructivist view (i.e. *responsibility of learning)* that learner autonomy should be seen as the ability or readiness of a learner to take charge of his or her learning. Dam (1995, cited in Chan (2001)) clarifies that this entails both a capacity and willingness on the part of the learner to act independently (and in co-operation with others) as a socially responsible person. In the same way, Linneweber-Lammerskitten et al. (2010) encourage both "teachers and learners to use the video clips as autonomously as they desire" (p. 33). Considering the vital role that the teacher plays in organising learning, particularly in the classroom, the present study focuses on how the teacher takes advantage of the given moment.

3.8. CONCLUSION

The purpose of this chapter was to provide a theoretical backdrop to the study. In an effort to gain insights into the learning offered by mobile technology, the following aspects were explored: constructivism (specifically social constructivism), active learning, interaction, and collaboration. In addition, visualization and the notion of learner autonomy were also briefly touched on as important aspects of this study. Although the notion of autonomy has been emphasised throughout this chapter, the important role of the teacher as an organiser of learning has been acknowledged and highlighted, a role that includes choosing, structuring and sequencing the learning process. The manner in which these aspects relate to the methodology of the study forms the basis of the following chapter.

CHAPTER 4

RESEARCH METHODOLOGY

4.1. INTRODUCTION

The focus of the study was to investigate how cell phones could be used in the teaching of Mathematics using VITALmaths video clips. This chapter outlines and reports on the methodology used in this research study. The structure of the chapter encompasses research goals, research orientation, sampling, data generation, data analysis, as well as issues pertaining to ethics and validity.

4.2. RESEARCH GOALS

This study seeks to explore teachers' and learners' experiences in the use of short mathematical video clips that can be viewed using mobile technology (i.e. cell phones). The central research question that frames the study is:

- How can cell phones be used in the teaching of Mathematics using VITALmaths video clips?

The primary intention is to find out how selected teachers integrate cell phones in their teaching of Mathematics. The increase in technology creates new challenges for teachers and raises new concerns about changes in the classroom organization. The role the teacher plays in negotiating these changes is critical and crucial to their success. Duffy and Cunningham (1996, as cited in Nanjappa & Grant (2003)) expand that the teachers' role of creating suitable contexts:

> is not merely providing learners with resources and letting them discover things for themselves, but organizing resources in such a way to engender cognitive dissonances in the minds of the learners, inspiring them to learn how to learn through a process of collaboration and defensible understandings. (p. 49)

4.3. RESEARCH ORIENTATION

This qualitative study is grounded in an interpretive paradigm (Babbie & Mouton, 2001) and aims to capture teachers' and learners' experiences using cell phones as an instructional aid in the classroom. According to Orlikowski and Baroudi (1991), interpretive studies assume that "people create and associate their own subjective and inter-subjective meanings as they interact with the world around them" (p. 5). Furthermore, Cohen, Manion and Morrison (2000) explain that:

> …the central endeavour in the context of the interpretive paradigm is to understand the subjective world of human experience. To retain the integrity of the phenomena being investigated, efforts are made to get inside the person and to understand from within. The imposition of external form and structure is resisted, since this reflects the viewpoint of the observer as opposed to that of the actor directly involved. (p. 22)

The primary goal of this qualitative study is to "describe and understand, rather than explain, human behaviour" (Babbie & Mouton, 2001, p. 270).

4.4. CASE STUDY METHODOLOGY

A case study methodology was adopted for this study. The case study is not a methodological choice *per se*, but rather a choice of the specific object to be studied (Stake, 1994). Two Grade 10 classroom environments, one in each of two schools in the Grahamstown region, formed the case in this study. The purpose of the study was to capture the complexity of teachers integrating cell phones into their teaching of mathematics in their usual environments. The unit of analysis was thus the experiences of the participating teachers as well as the classroom dynamics observed during the course of the teaching experiment.

4.5. SAMPLING

The research was carried out with two Grade 10 teachers in two schools in Grahamstown. As the two teachers are seen as important partners in this research, they were thus carefully selected for their experience and background knowledge of their students. This sampling was purposive (Cohen et al., 2007) because I carefully selected two research participants who were: (i) teachers taking part in the Mathematics Teacher Enrichment Programme (MTEP) of the FirstRand Foundation

(FRF) Mathematics Education Chair hosted by Rhodes University (MTEP provides professional development to the teachers), (ii) in schools located in the vicinity of Grahamstown, thus allowing ease of access, and (iii) currently teaching a Grade 10 class.

Since the case under study represents not only the teacher, but rather the dynamics of the classroom environment, the learners also formed an important element in this study sample. Focus group discussions were conducted with six randomly selected Grade 10 learners from each of the two classes. Grade 10 students were selected because they were mature enough to provide clear articulations and descriptions of their experience interacting with VITALmaths video clips. Grade 10 learners have already been exposed to the Theorem of Pythagoras in Grade 8 as well as Grade 9, thus the emphasis was to tease out from the learners aspects of conceptual understanding in relation to different approaches, explanations and proofs of the Theorem of Pythagoras.

4.6. RESEARCH DESIGN & DATA GENERATION

In order to enhance validity and reliability, this study made use of "triangulation"[13] through the incorporation of a variety of data collection techniques and methods, i.e. workshops with teachers, orientation lessons, observation, focus group discussions with the learners, and individual interviews with the two teachers. The data generation took place in three phases.

PHASE 1

(i) Workshop

As MTEP participants, the two teachers who took part in this study were already familiar with the five VITALmaths video clips on the Theorem of Pythagoras. The purpose of this initial workshop was thus not to introduce the teachers to the VITALmaths materials themselves, but rather to workshop ideas around how the video clips could form the basis of a Grade 10 Mathematics lesson. The initial plan

[13] "Triangulation may be defined as the use of two or more methods of data collection in the study of some aspects of human behaviour" (Cohen et al., 2007, p. 141).

was for the 2 teachers to select a VITALmaths video clip from the VITALmaths website (other than one of the 5 Pythagoras clips that would be used later in the research process), and together design a lesson and learning experience based on the chosen video clip. However, the 2 participating teachers were each teaching different topics to their Grade 10 learners, and they were concerned about digressing from their work schedule. A compromise was reached, and each of the 2 teachers selected a video clip that related to what they were currently teaching. Thus, rather than designing a learning experience based on the video clip, the video clip was simply incorporated into an existing lesson sequence. The researcher facilitated this process, and these lessons formed the basis of the next stage, the orientation lessons.

(ii) Orientation lessons

The purpose of the orientation lessons was to familiarise both the teachers and learners with (i) the experience of using cell phones in a classroom setting, and (ii) the technology itself. Cell phones are generally banned in the classroom, and as a result this was likely to be the first time that teachers and students were trying out using cell phones as an instructional aid. It was also important that the learners were familiar with the specific model of cell phone that was going to be used in the study and that any technical problems were dealt with before the commencement of the study.

The main aim of this orientation was to familiarize and orientate participants with the equipment and settings of the main study. Each teacher independently taught the lesson (which they had developed in the workshop) to their respective Grade 10 class. These lessons were video recorded not only to trial my own video recording skills but also so that the learners could become used to the presence of a video camera in the classroom. Upon completion of the orientation lesson, I had discussions with the two teachers to reflect on their experiences. This reflection process was used by each of the 2 teachers to independently design a 3-lesson sequence on the Theorem of Pythagoras using the five VITALmaths video clips that focused on this particular topic. These lesson sequences formed the basis of the next phase.

During Phase 1 I was also able to pilot my interview questions with the teachers as well as with a small number of learners. This allowed me to acquaint myself with the process of interviewing as well as to debug the instruments by modifying, where necessary, the questions planned for the interviews. In addition, since this study adopts an interpretive qualitative approach in which the establishment of relationships is important, this initial phase allowed for a general familiarization between researcher and research participants.

PHASE 2

Observation of lesson sequence

In this phase the two teachers each taught 3 lessons on the Theorem of Pythagoras, incorporating into the lesson sequence the five VITALmaths video clips relevant to the topic. These 5 video clips are described in Chapter 5 (section 5.4.). The five video clips were uploaded onto cell phones provided to the learners. Thirty Samsung SGH-i200 smart phones were donated by a leading mobile company for this purpose. Observation was my principal method of gathering information in this phase, and each of the 3-lesson sequences was video recorded. Cohen et al. (2007) suggest that observation "offers an investigator the opportunity to gather 'live' data from naturally occurring social situations" and allow the investigator to "look directly at what is taking place *in situ* rather than relying on second-hand accounts" (p. 396). Simpson and Tuson (2003) encourage that "if we are dealing with people, video recording can be a great help as it allows the same observation to be reviewed many times, with each viewing having the potential to elicit additional information" (p. 48).

PHASE 3

Interviewing was my second principal method of data collection, the main purpose was to triangulate[14] and complement information gathered through observation. As Tuckman, (cited in Cohen et al. (2007)) describes, an interview provides:

> .....access to what is 'inside a person's head', [it] makes it possible to measure what a person knows (knowledge of information), what a person

[14] "The general principle known as triangulation [is] collecting information from a diverse range of individuals and settings, using a variety of methods" (Maxwell, 1996, p. 75).

> likes or dislikes (values and preferences), and what a person thinks (attitudes and beliefs). (p. 350)

Furthermore, the method was selected because there is likely to be some data that cannot be obtained from observation. According to Gay and Airasian (2000) an interview enables the researcher to explore and probe participants' responses to gather more in-depth data about their experiences and feelings, and to examine attitudes, interests, concerns and values more easily than using observation. In addition, in interviews we encounter a living person, a person who can show us – through body language and tone of voice – how they feel about what they are talking about (Van der Mescht, 2011, p. 1).

There were two parts to Phase 3 – (i) one-on-one teacher interviews and (ii) learner focus group discussions.

(i) Teacher interviews

One-on-one "*semi-structured interviews*"[15] were conducted with the two teachers who took part in the study. These interviews were guided by a series of seven set questions related to the experience of using mobile technology in the classroom setting. Pertinent issues that were probed included aspects of how the cell phones supported learning, the relevance and usefulness of the video clips, the efficacy of the video clips, and the nature of the learner participation. Further questions probed areas of interest that opened up during the course of the interview.

(ii) Learner focus group discussions

The learner focus group[16] discussions involved six randomly selected Grade 10 learners from each of the two classes. These learners were randomly chosen from those who volunteered to take part in the focus group discussion. My interest here was to look into the learners' experience of using cell phone technology in the

[15] According to Cohen et al. (2007) a semi-structured interview is "where a schedule is prepared that is sufficiently open ended to enable the content to be recorded, digressions and expansions made, new avenues to be included and further probing to be undertaken" (p. 187).

[16] A focus group is a group of individuals, usually six to eight, brought together for a more or less open-ended discussion about an issue. This qualitative research tool provides a subjective, but not statistically valid, understanding of the larger community's attitudes. Retrieved October 1, 2011, from http://www.smallschoolsproject.org/PDFS/focusgroups.PDF

classroom setting with specific reference to their interaction with others, collaboration, and their exploration of the Theorem of Pythagoras.

All interviews/discussions were video recorded. This aided the analysis process by allowing for multiple viewings: “video recording can be a great help as it allows the same observation to be reviewed many times, with each viewing having the potential to elicit additional information” (Simpson and Tuson, 2003, p. 48).

Table 3: Summary of data generation phases

Phase	Activity	Data generated / description of activity
1	(i) Workshop	Ideas around how video clips viewed on cell phones could form the basis of a mathematics lesson. Design of a lesson using a chosen VITALmaths video clip.
	(ii) Orientation lesson	Orientation of learners and teachers to the technology involved in a learning experience using VITALmaths video clips on cell phones.
2	Observation of lesson sequence	Two 3-lesson sequences of each teacher on the Theorem of Pythagoras were carried out and video recorded.
3	Teacher interviews	One-on-one semi-structured interviews on teachers’ personal experience with the video clips and teaching with cell phones in the classroom.
	Learner focus group discussions	Learners’ personal experience learning with a cell phone and the efficacy of the videos clips.

4.7. DATA ANALYSIS

The primary purpose of the data analysis phase is to characterize the experiences of the teachers and learners with specific reference to the three lesson sequences based on the Theorem of Pythagoras. Data from the recorded lesson sequences as well as the teacher interviews and learner focus group discussions was used to establish specific themes in relation to the above topics. Terre Blanche and Durrheim (1999) advise that “analysis should not be seen as a separate phase that starts only after all data has been collected; rather the different phases shade into each other” (p. 154). Throughout the study, including the initial workshop and orientation lessons, I kept field-notes in the form of a journal to capture major observations and to begin categorising them into themes. Thereafter, viewing of the video recorded lessons

commenced and was repeated several times to be able to extract incidents and scenes that were relevant to the themes of the study. Themes gradually emerged from the data, and were refined over time with repeated engagement with the data. Themes were grouped to provide a rich characterization of learners' and teachers' experiences with using a particular application of cell phone technology for educational purposes (VITALmaths video clips).

4.8. ETHICS AND VALIDITY

Ethics is an important consideration in this study. Permission in the form of written consent was obtained from the Department of Education, the school principals of the two schools involved in the study, the two teacher participants, as well as parents/guardians of the learners who agreed to participate in the research (see appendix E – G). Issues of confidentially and anonymity were respected and retained throughout the study. As Stake (2003) reminds us, "qualitative researchers are guests in the private space of the world; their manners should be good and their code of ethics strict" (p. 154).

4.9. SUMMARY OF THE METHODOLOGY

The study was oriented in an interpretive paradigm within which I was able to use a case study method as a research approach. I opted for the use of observation and interviews as the key tools to ensure design coherence, validity and triangulation. The main instrument was observation, a video camera being used to capture all lessons.

Video data was complemented by interviews to cross-check and interrogate participants' personal experiences. Sampling was purposive because I carefully selected research participants who were Grade 10 teachers and who boasted good attendance in the MTEP programme of the FRF Mathematics Education Chair hosted by Rhodes University. Research sites were two schools in the Grahamstown region. The chapter concluded with a discussion of the data analysis protocol, as well as an interrogation of issues relating to ethics and validity. In the next chapter, the data is presented and discussed.

CHAPTER 5

RESULTS, ANALYSIS & DISCUSSION

5.1. INTRODUCTION

The purpose of this chapter is to present and discuss the results of the study. The primary objective of the study was to investigate how cell phones could be used to support the teaching of mathematics using VITALmaths video clips. The chapter begins by describing the context of each of the two chosen schools along with a description of the current school policy as it relates to cell phone usage. The five VITALmaths video clips are then described, as are each of each of the classroom lessons.

During the course of the data analysis (interviews, focus group interviews, video footage from recorded lessons) various themes began to emerge from the data. The chapter concludes with a discussion of each of these emerging themes: participation and engagement; collaboration; autonomy; speeding up of lessons; affective aspects; dynamic visualization; language issues; hands-on activities; and teacher enrichment. Although these themes are discussed individually, it is acknowledged that they are complementary, interrelated and overlapping.

5.2. DESCRIPTION OF SCHOOL CONTEXT

In this section I present a brief description of the school context in which the research was conducted. This is important as it clarifies both the nature of the school as well as the context in which the instruction takes place[17]. The research was carried out in two different high schools in Grahamstown, Eastern Cape. A Grade 10 class from each of the two high schools formed the focus of the research. Both schools are located in the township and are classified by the Department of Education as disadvantaged and non-fee paying schools. One school is situated deep in the township and the other one is on the edge of the township toward the town centre.

[17] Context also incorporates "…the wide range of environmental and situational elements that bear on instruction. For instance, educational policies, assessment of students and teachers, school organizational structures, school leadership characteristics, the nature and organization of teachers' work and the social matrix in which the school is embedded" (Kilpatrick, Swafford & Findell, 2001, pp. 314-315).

Therefore, for the purpose of this study and for ease of reference, the two schools involved are given the pseudonyms of *Deep High School and Edge High School* respectively, based on their location. Equally, other participants who took part in the study are referred to in terms of *deep* and *edge* to give a specific relation to one of the schools. For example: the teacher at Edge High School is given the pseudonym *Ms. Edge* while the teacher at Deep High School is given the pseudonym *Ms. Deep*. The two teachers who participated in this research happened to be both females. Students who participated in focus group discussions are coded as EFGI/P1(Edge Focus Group Interview, Pupil 1, for example) or DFGI/P4 (Deep Focus Group Interview, Pupil 4, for example) respectively.

Township schools are generally known to be under-resourced, a situation normally blamed on the past apartheid regime in South Africa. The Eastern Cape (EC), which comprises many rural and remote schools, is also well known for its general educational crisis and poor infrastructure. According to the NEIMS report (DBE, 2009), the EC has the lowest availability of ICT in schools. This predicament severely affects rural and township schools, making township schools an ideal case for this study.

Table 4: Statistical profile of the two schools

Schools	Total enrolment	Number of Mathematics and Mathematical Literacy teachers	Grade 10 students in the group that took part	Number of computers for teaching and learning	Cell phone prevalence (%) in Grade 10
Edge HS	1120	5	32	15	93.75%
Deep HS	382	5	15	0	66.67%

5.2.1. Edge High School

Edge High School is a day co-educational secondary school receiving State assistance. The school has a population of 1120 students enrolled from Grade 8 to Grade 12. On average there are 35 students in each class, which is the recommended South African average per class. Each teacher has their own classroom and students thus rotate from classroom to classroom. There are 5 Mathematics teachers who teach either Mathematics or Mathematical Literacy. Each lesson is 50 minutes long on a normal day. For the purposes of the study, Ms. Edge

preferred to use double lessons. Each of the video recorded lessons was thus approximately 1h40min in duration.

The school is in a reasonable condition, with good buildings, adequate furniture, large chalkboards and different laboratories (including a computer room). In the computer room there are 15 workstations donated by Rhodes University Education Department. When the computers were initially installed, students were encouraged to opt for computer training as an additional skill subject. This was an additional course, for which students had to pay an extra fee, focusing on basic computer skills. This initiative gradually stagnated and eventually came to a halt. A few years ago, the school's computer teacher was involved in training teachers in basic computer skills. This program also gradually weakened and eventually stopped. At the moment students do not go to the computer room anymore. Only teachers use this room now - for accessing educational resources, surfing the internet and compiling their instructional materials.

There are three computers for administration, one in the principal's office, another one in the deputy principal's office, and one computer for the secretary. Most of the teachers at the school are computer literate. Some were trained at the school while others received training by participating in the Khula Project of Rhodes University a few years ago. Ms. Edge had never received training in using ICT for teaching. She has a cell phone but like most "digital immigrants"[18] she too struggles with cell phone literacy such as using the internet, Bluetooth, downloading and sharing files etc.

5.2.2. Deep High School

Deep High School is also a State day secondary school situated in the heart of the same township in Grahamstown, approximately 7 km away from Edge HS. It is a unisex school that caters for 382 students from Grade 8 to Grade 12. There are five qualified Mathematics and Mathematical Literacy teachers. One of the Mathematics teachers is the head of department. Although the other two Mathematics teachers

[18] Prensky (2001) coined the term *digital immigrant* to refer to an individual who was born before the existence of digital technology but who has adopted it to some extent.

(including the HoD) were not involved in the study, they demonstrated keen interest in the VITALmaths video clips. During the trial phase of this study, the HoD personally took time to sit in our class for the whole lesson. Moreover, the other teacher also approached the researcher for information on accessing additional video clips. Each lesson on a normal day lasts for 55 minutes, and the teacher (Ms. Deep) opted to do the cell phone lessons on days when she had a double lesson (1h50 min long). Teachers have their own classrooms, and students move from classroom to classroom for different subjects.

Deep HS has many classroom blocks, and most of these are still in a fairly good condition. There is no computer room or laboratory, although there is an empty classroom which has been designated for computers. Currently the school has only a single computer, which they received as a gift from a colleague who transferred to another school some years back. This PC is used by the school secretary. One workstation found in the staffroom was apparently donated by a certain company for the sole purpose of recording daily weather. Only teachers, and a few students who are part of the weather recording project, have access to this computer to record weather information.

Ms. Deep has been trained by the Khula project and she also participated in another course in utilising ICT in education. She owns two cell phones but is less familiar with using cell phones for accessing the internet and for sharing files.

5.3. CURRENT POLICY AND USAGE OF CELL PHONES IN SCHOOLS

5.3.1. School policy on cell phones

The general position of many schools in South Africa, including the two schools in Grahamstown in which the research was conducted, is to ban cell phones and other mobile devices from the school grounds. The mantra about cell phones being disruptive in a school environment is claimed, for example: ringing cell phones and text messaging can disrupt classes and distract students who should be paying attention to their lessons; cell phones could be used to cheat in tests or exams; bullying and inappropriate photography or video recording are also a concern. The focus on their disruption of the educational process has come into conflict with cell phones becoming a convenient item over recent years. This situation also distracts

teachers from recognising and exploring cell phones as potential educational resources for themselves and their students.

At the Edge HS, the school rules stipulate that:

> While the school acknowledges that cell phones have become an important and useful means of communication, it is also aware of the fact that their use and abuse, particularly by children, pose social, ethical and safety consequences. The school would prefer students not to have cell phones in their possession while they are at school or in school uniform… (Edge HS, 2011 school rules)

The school gave a number of reasons to justify why this rule should stand. Some of the reasons include: students who have carried cell phones in public have been attacked and robbed of their cell phones, leaving some of them injured and traumatized; cell phone theft at school persists and causes unnecessary inconvenience; cell phones can be used to cheat in tests and exams; students accessing salacious and inappropriate content during lessons causes disruptions; and cell phones make students vulnerable to be approached and bullied by undesirable individuals. Ms. Edge confirmed this rule during her interview. In her own words she stated that "*when I started with this* [i.e. the research lessons which involved teaching with cell phones] *I was so sceptical because of the rule of the school that no cell phones are allowed"* (line 2). However the school rule also stated that students who insist on bringing their cell phones should have the cell phone switched off, not visible by others or by the teacher, and not on their person when writing test-like tasks.

At Deep HS, cell phones are prohibited on the school premises. According to Ms. Deep the school does not have a written rule yet, but students are made to understand that they are not allowed to bring cell phones into the classroom. In the event where a cell phone rings in the classroom, the subject teacher is expected to confiscate the cell phone and take it to the principal's office. The school will call the parent of the student in question to come and collect the cell phone from the office. If the parent shows up, he/she will be sternly warned not to allow the student to bring a cell phone again to the school. If no parent responds to the disciplinary invitation, the cell phone will be kept by the school and returned to the student at the end of year.

A consequence of the banning of students carrying cell phones while at school is that teachers have not considered exploring the potential of cell phones in terms of

educational opportunities or as broader information access points. Another contributing factor might be the fear[19] of the unknown and an anxiousness of opening the floodgates as teachers are afraid of various unknown repercussions if cell phones could be allowed in the classroom.

The literature reports that using technology as a teaching and learning tool in the classroom brings fear, anxiety and concerns to teachers since it involves both changes in classroom procedure and the use of often unfamiliar technologies (Bitner & Bitner, 2002 as cited in Nangue, 2011, p. 68). This fear and anxiety influences the teacher's choice of pedagogy, instruction strategies and delivery. During the course of the study both participating teachers expressed discomfort with their own lack of skills in terms of integrating cell phones into their teaching.

5.3.2. Students and cell phones

At Edge HS, 32 learners (17 boys and 15 girls) doing Mathematics in Grade 10 took part in this study. Their ages ranged between 15 – 19 years old, the majority of the students being 16 years old. 30 students, which represents over 90% of the class, owned a cell phone at the time of the study. Of the other two, one had had his cell phone broken, while the other student's cell phone had recently been stolen. All six students who took part in the focus group discussion in this school had cell phones.

The Grade 10 Mathematics class at Deep HS contained only boys, 15 in total, aged between 15-18 years old (average age 16.7 years). 10 students (66.6%) owned cell phones. The remaining five boys didn't have their own cell phone but confirmed that they used relatives' cell phones at home sometimes. As with Edge HS, the school prohibits cell phones on the school premises.

To summarise, even if students own cell phones, both schools' rules and regulations strictly prohibit students from bringing cell phones onto the school premises. This policy regulation is monitored seriously despite the fact that technology has

[19] This same fear came out of the questions time when I presented a paper on "how I teach with cell phones" at the AMESA (Association for Mathematics Education of South Africa) 2011 conference at Wits University (Samson & Ndafenongo, 2011). The concern raised at the AMESA congress was the immoral use of mobile phones by students.

generated positive effects in education. It is interesting to observe that cell phones, which are one of the most cost effective and user-friendly pocket technologies in terms of potential educational affordances, are still viewed by these under-resourced schools as being little more than a harmful irritation when on the school premises. This results in a "disconnect" between how students use technology for every day communication and how they use technology in the classroom (Kolb, 2008).

To clarify, the cell phones used in the study were 30 Samsung SHG-i200 cell phones sponsored by a leading cell phone network company in South Africa. These cell phones were loaded with VITALmaths video clips and handed out to students during the lesson presentation, and then returned after the lesson. It was not a condition of the study to ask students to bring their own cell phones to class.

5.3.3. Students and cell phone use

With regard to the general use of cell phones by students, students identified a variety of activities for which they used cell phones. In the focus group discussion at Deep HS (DFGI/All) students responded jointly that they use a cell phone at home to make calls, obtain information from the internet, use MXit, calculate, access Facebook, play games, listen to music, watch videos, take photos, and message.
At Edge HS, the 6 students in the focus group discussion (EFGI/All) identified the following activities in which they engaged a cell phone: socialising through MXit and facebook, receiving and making calls, text messaging, setting alarms and reminders, checking time, listening to music, watching news, taking pictures, sending and receiving emails, and playing games.

In summary there were about 15 different activities that really keep young users fastened to their cell phones. These activities are only carried out at home because at school cell phones are prohibited. However, according to Kolb (2008) there are researchers who have studied the disconnect between students' home life and students' experiences in school and concluded that if the home culture of students is integrated into their classroom learning, they are more likely to be academically successful.

In the next section, I will describe briefly the five VITALmaths video clips on the theorem of Pythagoras. These Pythagoras video clips were the only ones used in this study to investigate how cell phones can be used in the teaching of mathematics.

5.4. DESCRIPTION OF THE VITALmaths VIDEO CLIPS

Five VITALmaths video clips (www.ru.ac.za/VITALmaths) were chosen to introduce the Theorem of Pythagoras in a progressive manner. These video clips will be briefly discussed by using a number of screenshots (see also Samson & Ndafenongo, 2011).

5.4.1. Alex's proof of Pythagoras

The video begins with a proposal for a visual proof of the Theorem of Pythagoras. The question is raised as to whether or not this constitutes a *general* proof. The activity involves drawing a right-angled triangle with the perpendicular sides in a 2:1 ratio. A square is then added to (or drawn on) each of the perpendicular sides. The smaller square is cut out and the larger square is cut into 4 pieces as shown in the middle diagram of Figure 2. These 5 pieces are then re-arranged in order to show that together they equal the area of the squares on the hypotenuse of the right-angled triangle.

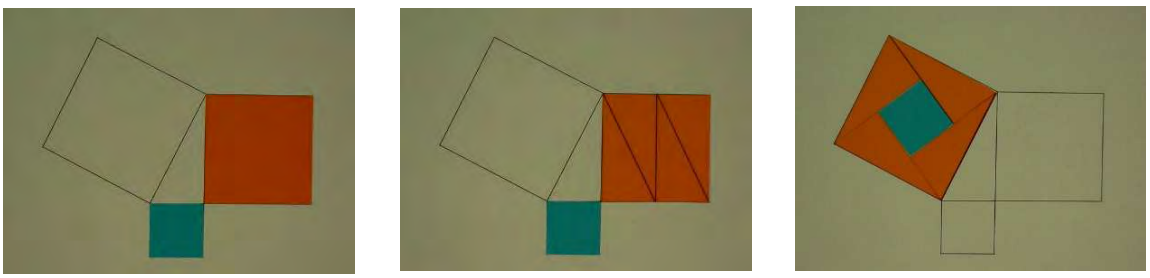


Figure 2: Alex's proof of Pythagoras

This proof of Pythagoras only works when the right-angled triangle's perpendicular sides are drawn in the ratio of 2:1. The main idea is to encourage exploration and debate by teasing out whether or not this constitutes a *general* proof of Pythagoras' theorem.

5.4.2. Ben's proof of Pythagoras

This video begins with another proposal for a visual proof of the Theorem of Pythagoras. Again the question is raised as to whether or not this constitutes a *general* proof. The activity begins by drawing a right-angled triangle with the perpendicular sides in the ratio 3:1. A square is then constructed on each of the perpendicular sides. The smaller square is cut out and the larger square is cut into 4 pieces as shown. These 5 pieces are then re-arranged in order to show that together they equal the area of the square on the hypotenuse of the right-angled triangle.

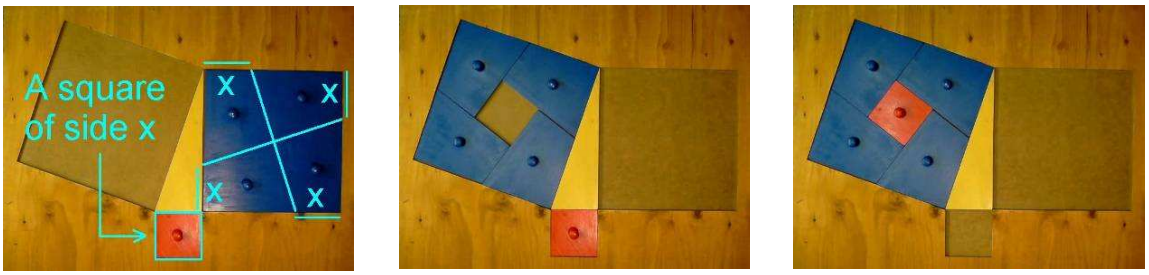


Figure 3: Ben's proof of Pythagoras

Ben's proof of Pythagoras only works when the right-angled triangle's perpendicular sides are drawn in the ratio 3:1. Like Alex's proof of Pythagoras, the main idea is to tease out whether or not this constitutes a *general* proof of Pythagoras' theorem. The idea is for students to explore Ben's proof of Pythagoras using right-angled triangles with different measurements in order to engage in classroom exploration and discussion.

5.4.3. Discovering right-angled triangles (In German)

The activity in this video involves arranging three squares (from a selection of differently sized squares) vertex to vertex to form an enclosed triangle. The idea is to find combinations of squares (i.e. Pythagorean triples) that from a right-angled triangle.

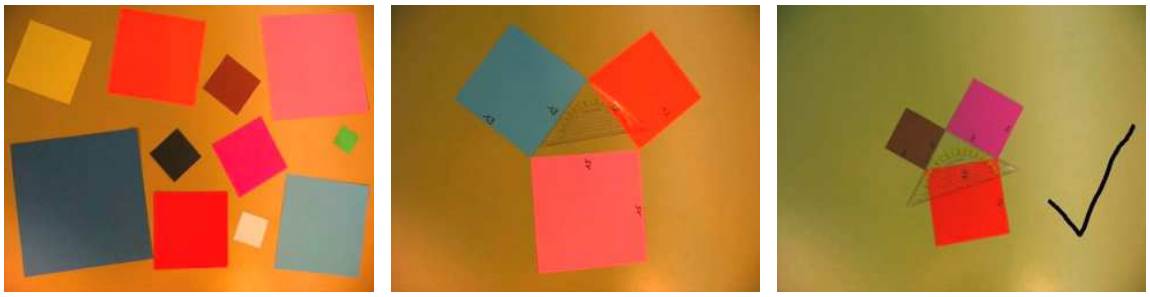


Figure 4: Discovering right-angled triangles

5.4.4. Sum of two squares

In this video the following question is investigated: Is it possible to construct a third square whose area is the sum of two given squares? The activity begins by constructing two squares, advisably a small square and a bigger square, using own measurements. Thereafter the small square is used to break down the bigger square as shown below.

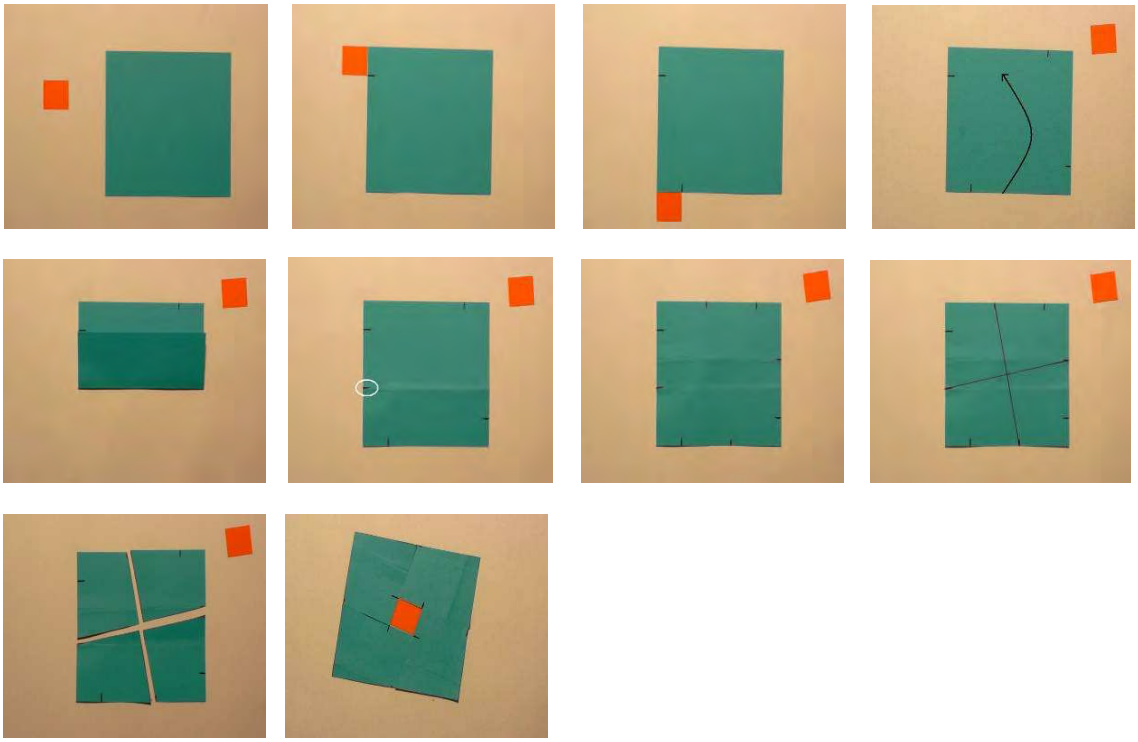


Figure 5: Sum of two squares

It is then shown that the five pieces can be put together to form a third square. The whole idea is to get students to critically connect this idea to Pythagoras' Theorem.

5.4.5. The theorem of Pythagoras (In German)

This video uses another striking visual approach to demonstrate the Theorem of Pythagoras. The activity includes the drawing of four congruent right-angled triangles (they can be duplicated to make 8, if necessary). A square sheet of paper is then used such that the side of the square sheet is equal in length to the sum of the two shorter sides of the drawn right-angled triangles. The object of the exercise is to use the four triangles to cover the square sheet of paper so that the uncovered area is a square. The process is then repeated such that the uncovered area is now in the form of two squares. These two representations are shown in Figure 6.

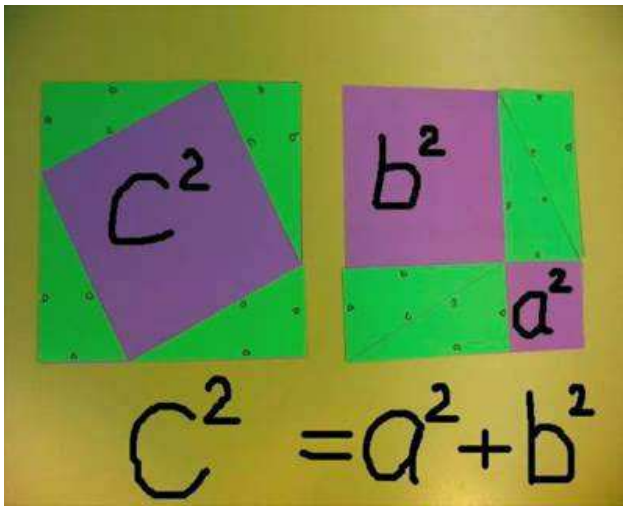


Figure 6: The theorem of Pythagoras

The whole idea is to get students to critically identify and explain how the two diagrams shown in Figure 6 relate (a) to each other, and (b) to the theorem of Pythagoras.

In the next section I present brief descriptions, along with video snapshots, of each of the 6 lessons (three lessons from each teacher) video recorded during the study.

5.5. DESCRIPTION OF LESSONS WHERE CELL PHONES WERE INCORPORATED

As emphasised by Kilpatrick et al. (2001) the biggest challenge for teachers is how to manage instruction in such a way that it assists the learning process. The primary objective in describing these lessons is to highlight how teachers managed classroom instruction when incorporating cell phones into the teaching process.

These descriptions aim to characterise the video recorded data as a precursor to its later analysis. These descriptions and snapshots include both the instruction that takes place as well as brief descriptions of learner engagement. These narrative descriptions are mere stories that tell what happened in each of the six lessons, and are thus free of qualitative commentary.

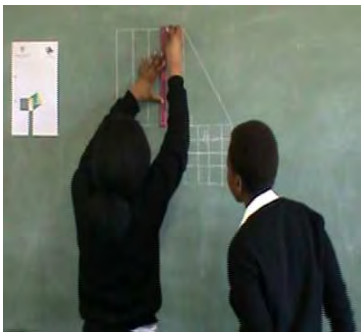
The structure of the lesson descriptions is arranged in such a way that I will first describe the first lesson of both teachers, followed by their second lessons, and finally their third lessons. This structure is aimed to point out that the teachers didn't necessarily use the same VITALmaths video clips in identical ways.

Ms. Edge's Lesson 1: Using Alex's and Ben's proof of Pythagoras

Ms. Edge began the lesson by slowly distributing a prepared worksheet along with required materials such as the cell phones pre-loaded with the VITALmaths video clips, square grid paper, scissors, and mathematical sets which included set squares and rulers. Because the worksheet contained instructions, many students began engaging with the worksheet while Ms. Edge handed out the various resource materials. While continuing to distribute the materials, she informed the class that they would be working in pairs.

Although the students were already ahead with accessing the clips on the cell phones, the teacher went on to repeat the instructions on how to access the video clips using the cell phones. The students then watched the videos. For almost 15 minutes the class was very quiet as students engaged with the content in the prescribed VITALmaths video clip on the cell phones. While this took place, Ms. Edge walked around the classroom talking softly to pairs of students.

Some students had already started sketching their triangles on the square grid paper provided. However, Ms. Edge stopped the whole class and instructed students to draw the triangles with leg sides in the ratio 2:1 in order for the experiment to work as shown in the cell phones. After a long while of students working, the teacher identified the first group that had almost completed the task. The teacher then asked for the attention of the whole class to allow this group to share their work with the class on the chalk board. What was fascinating was that the group presenting on the chalkboard used a set square to accurately draw the squares on the leg side, something that was not explicitly demonstrated in the video clip.


Above on the far left is an example of two students working together collaboratively. In the next two snaps is their chalkboard presentation. The photo on the far right shows the use of a set square to accurately draw the perpendicular corner angles of a square.

The lesson proceeded with Ms. Edge encouraging students to try a similar experiment with triangles whose two shorter sides were not in the ratio of 2:1. She indicated that a different pair of students would be invited to share their results on the chalkboard. After a short while she noticed that the same pair that had presented previously was almost done. Rather than getting the same group to present again she encouraged the other students to work harder and faster so that she could choose a different pair to present their work. She managed to get a different group to present on the chalkboard in a short span of time. However she also displayed the work of the faster group in order to emphasise that other measurements not in the ratio 2:1 will not work in Alex's proof of Pythagoras.

She then immediately asked students to quickly watch the VITALmaths video clip on "Ben's proof of Pythagoras" on the cell phones, and to carry out the experiment. She again encouraged that a different pair should report back to the whole class after they had successfully completed the experiment. She also instructed the students to use the ratio 3:1 to draw the legs of the right-angled triangle (the ratio 3:1 is the only ratio for which Ben's proof of Pythagoras works). 20 minutes later a number of different groups had successfully completed the exercise/investigation and were eager to be given a chance to present on the chalkboard. Ms. Edge chose a group that hadn't previously been chosen to report back to the whole class. She also noticed that her faster pair had failed to use the ratio 3:1, but instead had used 4:1. She used their work to demonstrate that if the ratio is not 3:1 then the visual proof would not work.

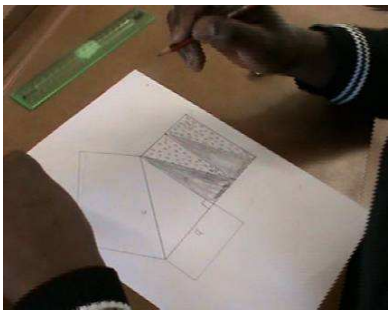
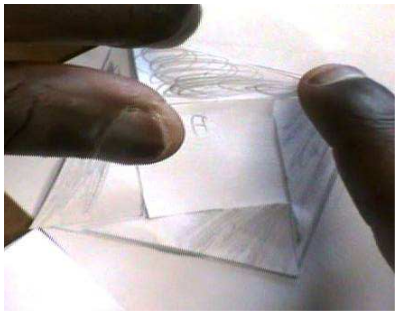
She then concluded the lesson by making reference to the two investigations, and emphasised the students' findings. She ran through a numerical example of using the Pythagoras theorem and requested students to do the rest of the practice activities in the worksheet at home as homework.

The next description illustrates how Ms. Deep of Deep HS incorporated the same VITALmaths video clips on Pythagoras' theorem into her first lesson.

Ms Deep's Lesson 1: Using Alex's and Ben's proof of Pythagoras

Ms. Deep began her lesson with a brief whole-class discussion that was designed to recap anything about right-angled triangles. During this discussion, students mentioned things like "90°", "the longest side is called hypotenuse". In addition, one student volunteered to draw a right-angled triangle on the chalkboard. The teacher acknowledged these responses and proceeded to ask students challenging questions on "hypotenuse" and "Pythagoras' theorem." The teacher then described the activity she wanted the students to work on for the remainder of the lesson. She said "we are going to learn how to prove the theorem of Pythagoras".

She quickly started distributing to each student a cell phone, blank page, ruler, pencil and eraser. She instructed students to switch on their cell phones and to watch the VITALmaths video clip on Alex's proof of Pythagoras. In guiding the students she instructed that students should draw a right-angled triangle with perpendicular sides 3cm and 4cm on a blank sheet and then add squares on both sides. At the same time Ms. Deep urged students, who were working individually, to work as fast as possible. Since Alex's proof of Pythagoras only works with a right-angled triangle with perpendicular sides in the ratio of 2:1, not 4:3 as Ms. Deep instructed, none of the students were able to succeed with the activity. In addition, many students drew incorrect diagrams by drawing inaccurate squares on the perpendicular sides. In some instances these "squares" looked more like rectangles or parallelograms.


On the far left snapshot above is an example of inaccurate squares which were drawn by most of the students. The next two snapshots shows how students struggled with the exercise as a result of using the inaccurate squares

Ms. Deep only became aware of the problem very late in the lesson, and couldn't do much to put matters right. She instead instructed those students who were done to proceed to the next activity - Ben's proof of Pythagoras. She then started to distribute blank pages again.

Students continued to work and talk among themselves in isiXhosa, the teacher also spoke most of the time in isiXhosa to individual students. There was no instruction about the measurement to use, so students used their own measurements. Therefore, this part of the lesson as well yielded little pleasure for students. Despite the observation that students were really engaged in the whole lesson, their investigation failed again since Ben's proof of Pythagoras only works for right-angled triangles with perpendicular sides in the ratio 3:1.
Students kept redrawing new shapes until the bell rang to indicate the end of the lesson. The teacher couldn't conclude the lesson because time ran out. Neither could she give practice activities. Instead she asked students to try the experiment at home again. She dismissed the students who were still busy working about 10 min after the bell rang.

The next description illustrates how Ms. Edge structured her lesson 2.

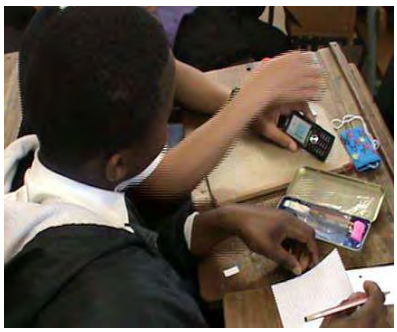
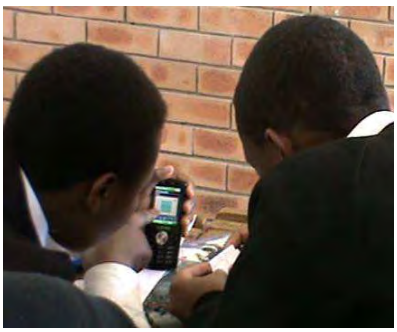
Ms. Edge's Lesson 2: Using "Sum of two squares" video clip[20]

Once the students had entered the classroom and seated themselves, Ms. Edge greeted the class: "good morning class". All students stood up and returned the greeting enthusiastically. Ms. Edge then explained to the class that the video clip they were going to be using that day contained German text, but she encouraged the class to try nonetheless to make sense of the video clip. The students were apprehensive about doing this, and finally it was agreed that the students should rather watch the remaining English video clip related to Pythagoras' theorem - "sum of two squares". While this discussion was in progress, Ms. Edge was simultaneously distributing materials in the class. Once the materials had been distributed, the whole class started watching the selected video clip on the cell phones. There was total silence in the classroom for about 7 minutes as students engaged with the video clip on the cell phone.

After a few minutes the teacher reminded the whole class to construct their own two squares (as shown in the video clip) and to construct a third square from the two smaller squares using the idea illustrated in the cell phone video clip. She continued to walk around the class,

[20] As I was setting up the video camera, Ms. Edge started explaining to me how she planned to teach this class. Ms. Edge planned to use a VITALmaths video clip on "sums of odd numbers" instead of one of the three remaining clips on Pythagoras' theorem. As a result, I explained to her why we should keep to the Pythagoras theorem, and she agreed to immediately adapt her lesson, which was about to start, to incorporate one of the Pythagoras video clips.

helping pairs to catch up with the content, and motivating them in different ways. During this time there was general student-to-student discussion as students interacted with the content of the video clip. At one occasion Ms. Edge remarked that it seemed like all pairs were succeeding since she had heard many students excitedly remark “it works!”.


In the snapshots above we see different students engaged with the VITALmaths video clips on the cell phones.

Thereafter, she took class work from one pair of students and pasted it on the chalkboard at the front of the class. She expanded on the idea in the video clip and pulled the threads together from the previous lesson on Alex’s and Ben’s proof of Pythagoras. She did this by posing questions to the students, challenging them to reflect on the pervious lesson. She emphasized the meaning of the exercise they had just completed - that for “any two squares, regardless of the measurement, the experiment will work.”

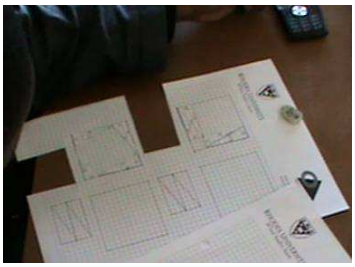
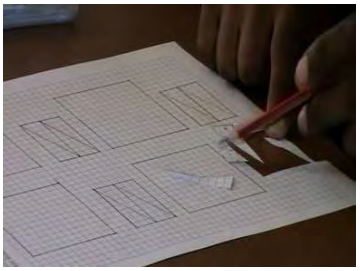
At the end of the lesson, one student raised her hand persistently. When she was allowed to speak, she said “it doesn’t matter what size are your squares, but if you cut it out wrongly it won’t work.” The teacher excitedly thanked the student for the beautiful comment.
Ms. Edge ended the lesson by motivating students and saying that learning mathematics needs hands-on activities to be able to master concepts. She finished by saying that one thing about maths is that “maths is fun!”

Next is a description of Ms. Deep’s second lesson. For this lesson Ms. Deep used two video clips: “The theorem of Pythagoras” (*in German*) and “Sum of two squares”.

Ms Deep’s Lesson 2: Using “The theorem of Pythagoras” and “Sum of two squares”
Ms. Deep started this lesson with a brief recap of the previous lesson’s discussion of Pythagoras’ theorem and right-angled triangles, emphasising the technique to identify the hypotenuse – the longest side in a right-angled triangle which is opposite the angle of 90 degrees. She also recapped on the formulae for calculating the area of triangles, squares and rectangles. However, her questioning strategies were limited and highly directed toward getting students to say the correct answers. Students responded by chanting the prompted answers.

After the recap, Ms. Deep announced that the class would be going to do another activity to prove the theorem of Pythagoras. Quickly, Ms. Deep started to distribute materials to the students: a square grid paper with pre-drawn diagrams, pencils and cell phones. While distributing the materials she also instructed that students should work in pairs. She then asked the students to watch the VITALmaths video clip “The theorem of Pythagoras”. Although this particular video clip contains German text, Ms. Deep encouraged her students to watch it carefully as she expected students to mimic what they saw in the cell phone video clip.

Thereafter, she called for students to cut out the pre-drawn shapes on the distributed square grid paper and arrange them according to what they had just seen in the video clip. She reminded them to label the sides of the triangle as *a* and *b* for the length and breadth respectively. In helping students Ms. Deep was trying to explain to the students how to prove algebraically that when four triangles are arranged in the bigger square (see Figure 6. in Section 5.4.5) the remaining area is equal to the area of the square sheet minus the area of the four triangles. She was also insistent on students being able to express this algebraic relationship in terms of *a* and *b*.

After a long while of investigation and algebraic calculation by students (as shown in the snapshots above), the teacher instructed the students to abandon the first activity and embark upon watching the next video clip: "The sum of two squares". She then handed out another sheet with two pre-drawn diagrams (a small square and a bigger square). After watching the video students started to cut out the two squares, using the smaller square to make marks on the bigger square, and finally cutting the larger square into four congruent quadrilaterals. It appeared that many groups of students succeeded with this activity far better than with the previous one.

In concluding the lesson, Ms. Deep wrote on the chalkboard the statement "the Pythagoras theorem states that the area of the squares on the two sides is equal to the area of the square on the hypotenuse". She read it to the students, and emphasised how this statement was demonstrated in the first video clip. The lesson was then adjourned.

The next two descriptions represent the last lessons of the two teachers.

Ms. Edge's Lesson 3: Using "The theorem of Pythagoras" and "Discovering right-angled triangles

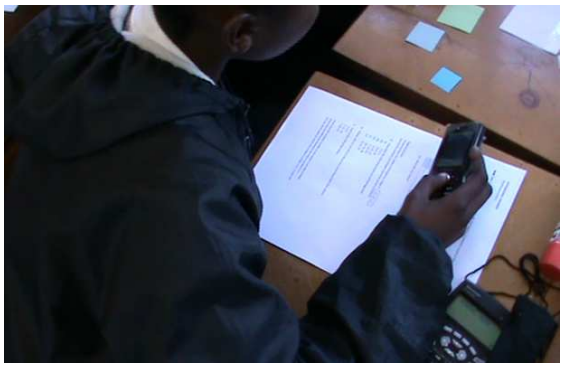
In this last lesson Ms. Edge looked very well prepared. She started her lesson by informing students that they would be working in pairs again. She continued to distribute a worksheet, cell phones and other materials to each pair. She checked whether all students were comfortable with the cell phones settings, and then asked them to watch the video clip "The theorem of Pythagoras" which was in German. She encouraged students to work fast so that one pair could share their results with the rest of the class.

Students started drawing some diagrams in their note books or exam pads, trying to mimic what they had viewed in the video clip. They worked collaboratively to draw, cut out, and paste the various shapes as demonstrated in the video clip. The fastest group (the same pair who usually completed their work first) was invited by the teacher to share their results with the whole class.

In the picture above two students from the fastest group present their investigation results to the rest of the class. It was noticeable that the majority of students were watching.

After the group had finished presenting, with the support of the teacher, Ms. Edge asked the students to move on to the next task. She said “use the cell phones to watch the video clip on “discovering right angled triangles” also in German”. She encouraged the students not to fear the German text anymore as they had been able to grasp the previous video clip which was also in German. She also handed out a set of differently sized squares to each group. Immediately, students started to arrange three of the differently sized squares (vertex to vertex) to form a triangle in the middle. The students then used either a set square or protractor to find out whether the enclosed triangle was right-angled. If one of the angles of the triangle was 90 degrees, students had to measure the dimensions of each of the three squares and enter the result into a table provided in the distributed worksheet. They also had to calculate the area of each of the three squares that produced the right-angled triangle. These results were entered into the same table alongside the length of each side. In one column, students also had to add together the areas of the two smaller squares and compare it with the area of the bigger square. While working in pairs, one student generally did the arrangement of squares and the measuring of sides, while the other student completed the table and performed any required calculations. During this time, students were talking, sharing results and helping each other. Extra support was provided by the teacher who was constantly moving around the classroom checking the progress of each pair.

Ms. Edge then asked the class if there was a different group that was ready to come to the front to share their results.



A different group (pictured above) emerged and pasted three diagrams on the chalkboard. They continued to explain to the whole class that they had measured the largest angle and confirmed that it was 90°, so they had proceeded to measure each side of each square and

found their lengths to be 1.5 cm, 2 cm and 2.5 cm. They squared the lengths to find the area of each square and got 2.25 cm^2, 4 cm^2 and 6.25 cm^2 respectively. When they added the areas of the two smaller squares together they found that the added areas together were equal to the area of the bigger square.

The teacher then instructed the students to move on to Task 3 on the worksheet. This activity was about Pythagorean triples. In the worksheet there were sets of triples that students had to investigate to see if they conformed to the Pythagorean statement $a^2 + b^2 = c^2$. Thereafter, students confirmed through calculation that all the given triples were indeed Pythagorean.

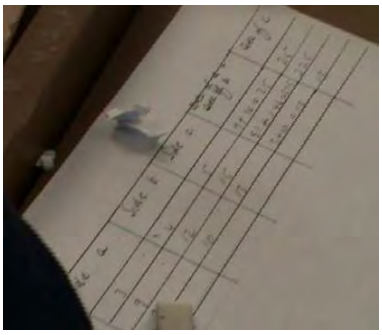
In concluding the lesson, Ms. Edge expanded the students' knowledge by showing them how to find other Pythagorean triples by using a simple algorithmic procedure. She carried out one example on the chalkboard and then asked two students to come to the chalkboard, one after the other, to do calculations similar to her example. All students' work was done correctly. Ms. Edge then closed the lesson by encouraging students to personally reflect on what they had learned on Pythagoras' theorem thus far.

The last description briefly shows Ms. Deep's final lesson in which she used the German video clip "Discovering right-angled triangles".

Ms. Deep's Lesson 3: Using "Discovering right-angled triangles"

The lesson started with Ms. Deep distributing a 5-minute class activity on using Pythagoras' theorem to calculate missing sides of various right-angled triangles. Students started working on the class activity immediately. It was interesting to note that although there were no calculators available, a number of students made use of the calculator facility on their cell phones to aid the process of calculation.

After about 13 minutes the teacher stopped the class activity and asked students to move on to the next activity. This activity involved watching the video clip "Discovering right-angled triangles" which contained German text. In addition to cell phones, each student was also given a square grid sheet of paper with differently sized pre-drawn squares, as well as a table to be completed during the activity. The students first watched the video clip and afterwards started cutting out the squares. Students started to imitate the demonstration in the video clip while receiving extra individual support from the teacher. After a short while two students at the back had completed the investigation (*putting three squares vertex to vertex to form a triangle in the middle and then measuring the largest interior angle to find out if it was 90 degrees, and finally completing the provided table*). Ms. Deep asked this pair of students to assist other students in completing the task.


The far left snapshot above shows students placing squares vertex to vertex and

measuring the largest interior angle of the triangle formed. Once they get a set of three squares that forms an angle of 90°, they count the units on the side of the square and fill the lengths in the table (middle snapshot). In the last snapshot (far right) a student is seen assisting fellow classmates, encouraged to do so by the teacher.

She later intercepted this activity and handed out another sheet of class activities to the students. The activity in this sheet was taken from a Grade 8 textbook and required students to identify from a table two perfect square numbers that added up to another perfect square. Students completed this exercise very quickly, and the teacher asked one pair of students to present to the whole class on the chalkboard how they managed to finish so quickly. One student from the group sitting at the back stood up, walked to the chalkboard and explained in isiXhosa that the activity was similar to the one they had just been doing with the cell phones, and that the numbers required in the new activity mostly resembled those that were found in the earlier activity – i.e. the Pythagorean triples. The student added that if you looked at your previous activity carefully, it could help you to find these three prefect squares.

Students continued to work until the teacher stopped the lesson for the day.

In the next section I will present and discuss the various themes that gradually emerged during the analysis of the video recorded lessons, the individual teacher interviews, and the student focus group interviews.

5.6. EMERGING THEMES

The data analysis process involved repeated engagement with the data using an iterative approach. For example, video recorded lessons were viewed several times, using the interview transcripts to look for and corroborate a specific classroom activity. During this process various themes and common threads gradually emerged. Similar views or perceptions from teachers and students were colour coded, grouped and categorised with a fitting topic (theme).

The themes that emerged relate to: participation and engagement, collaboration, autonomy, speeding up of lessons, affective aspects such as motivation, dynamic visualization, language issues, hands-on activities, and teacher enrichment. Although these themes are discussed individually, it is acknowledged that they are complementary, interrelated and overlapping.

5.6.1. Participation and engagement

A strong thread running through the responses of both teachers and students is that there was active participation and excellent engagement in the lessons which

incorporated cell phones. This matched what Attewell (n.d.) envisioned - that the enthusiasm of young students for mobile phones can be harnessed to encourage participation in education. While social constructivists maintain that participation and engagement are important in knowledge co-construction, they stipulate that authentic learning takes place in situations where learning simultaneously involves listening, seeing, doing, participating and reflecting. In fact, active participation and engaging students are critical aspects in social constructivism as they allow students to make their own meaning (Sigel & Cocking, 1977; Von Glasersfeld, 1983, 1989; Bonwell & Eison, 1991; Jonassen, 1991). Various elements of participation and engagement cropped up several times during the process of reviewing and scrutinising data.

According to Ms. Edge, students' participation was extremely impressive: students were enthusiastic, very active and fast. She also pointed out that students seemed to grasp concepts easily and quickly, as indicated by students giving out exclamations such as: *okay, yeah* etc. These exclamations seemed to suggest that students were personally convinced by the results of their investigations. In responding to the 5th interview question ("What was the nature of students' participation when working with cell phones compared to the usual classroom settings?") Ms. Edge answered:

> *Yoh! I…I…I saw something that I never saw in my class; everybody participated. I usually get shy learners in my classroom who don't want to talk, I usually get learners who uh, hide behind the other learners, but when I was using this cell phone thing, everybody was participating. To me it says it sparkle their interest.* (line 20)

She added that she normally struggled to get feedback from home work and class work. However, she said "*this time around you give them a piece of work to do they are all there and each one wants to respond...*" (line 30). This indicates that students were engaged with the lesson and actively participated in the proceedings of the lesson.

On her part, Ms. Deep also found the lessons to be engaging because students were required to carefully observe and make sense of details and procedures from the cell phone video clips in order to be able to implement and apply what they had seen. She noticed that since the video clips required students to prove things for themselves without being told what to do every step of the way, this aspect of the cell phone lessons really encouraged engagement. She elaborated: "*when they are*

involved in the lesson, they participate more than when you are … in front of them" (line 83). Ms. Deep overwhelmingly expressed that:

> *at least they* [i.e. the students] *were free to talk. They were talking and they…they were enjoying it. Even everyone, those, even those I use to ask them to come to the board and do some work…and those, those who are shy, it's very rare to see them on the board, but when they were using the cell phone, everyone was busy, excited, doing…even, I was so surprised, even those who are shy, were those who were helping others…* (Line 53)

These comments demonstrate that students were verbal in the classroom as they interacted, participated and engaged in the lessons. In addition, group participation allowed shy students to be more confident by allowing a space for them to feel comfortable.

To summarize, both teachers indicated that students' concentration was good, beyond their expectation. They attributed this to students wanting to take hold of what was being viewed on the cell phone in order to be able to follow and reproduce the activities themselves. Students observed by the teachers were reported to have been active, very busy, talking and enjoying the lessons. Encouragingly, both teachers highlighted that shy students were in top form and participated outstandingly in all three lessons even to the extent of helping the usually faster students to cope with the technology. In addition, teachers pointed out that students were willing to learn, participate, submit or share their findings and solutions with the teacher and other students which in turn served as a motivation to other students and provided valuable feedback to the teacher.

Student remarks from the focus group interviews corroborate the comments and observations of the two teachers. EFGI/P3 commented that usually in the classroom when they are given a task some students do it while others simply don't, but during the lesson with cell phones everybody participated and everybody did what they were supposed to do. EFGI/P4 agreed with EFGI/P3's observation and elaborated that everybody participated because they wanted to share their results or solutions with the rest of the class which was quite different from normal class activities without cell phones where some students simply don't care.

Student EFGI/P3 testified that sometimes she gets bored in her usual classes, because some days the teaching is not always good, so she would sleep or read a book just to distance herself from the lesson. However, she stated that in the lessons

with cell phones she never got bored. EFGI/P5 agreed with EFGI/P3 and added that he also gets bored when the teacher is standing in front teaching. Other participants commented that normally the teacher keeps talking too much and that is what they claim results in students losing focus in the class.

Participant DFGI/P1 observed that everyone was excited and interested in using cell phones in the classroom. DFGI/P2 remarked that:

> *...people focused more when they are using cell phones because you know you have to look at the video and make sure what is seeing here. So if one thing flash off you won't know what is going on. (line 335)*

DFGI/P2 contested that:

> *Sometimes the books are boring. Sometimes they are like black and white colours…that colour is boring. And then when you are watching the cell phone then there is different views, then it seems interesting (line 340).*

This remark resonates with Prenky's (2001) argument that "digital natives[21] are used to receiving information really fast … They prefer their graphics *before* their text rather than the opposite" (pp. 1–3).

There are a number of common observations that teachers and students have described as elements that have contributed to the type of participation and engagement that took place in the two classrooms during the 6 lessons of the study. Ms. Deep and Ms. Edge both remarked that students' participation was active, fast and everybody participated, a view that was echoed by many students. It was observed that the active participation and excellent concentration was facilitated or encouraged by students having to carefully observe the various activities and scenarios demonstrated in the video clips (viewed on the cell phones) in order to be able to replicate the investigation.

Teachers talked about the overwhelming willingness of students to share their results and findings. On this point, EFGI/P5 also believed that it served as a motivation to many students to be engaged in the lesson, to finish first and to be given a chance to report back to the whole class. The video record shows that even if not all students got a chance to report back to the whole class, those who successfully completed

[21] Digital natives refer to today's students in K through to College who represent the first generation to grow up with this new technology (Prensky, 2001, p. 1).

their tasks were able to share their excitement with their neighbours or show the completed tasks to the video camera.

5.6.2. Collaboration

In terms of collaboration, Bell et al. (1985) suggest that students working collaboratively are more successful than when working alone. This section presents the findings related to collaboration: working together and supporting each other to achieve a common goal. From the lesson description, it is clear that in most lessons students worked collaboratively - either in pairs or groups of three as instructed by their teacher. Collaboration is a key element in terms of the Zone of Proximal Development (Vygotsky, 1978) whereby students have the potential to achieve skills that they cannot attain on their own, but which become attainable when working together with more knowledgeable others.

The focus group interview at Deep HS revealed that in general students found that working in pairs or groups was useful in that they were able to share knowledge and ideas (DFGI/P2, line 288 and DFGI/P5, line 298). DFGI/P4 explained that "*others might not understand the things. So, when you are working together you can explain to them or they can explain to you what they know*" (line 293). Students also commented that when you made a mistake your partner could tell you that it was wrong. DFGI/P4 expanded by explaining that when you are working with a partner you can explain to them more easily because some students, when they are working alone, are afraid to ask the teacher about what they do not understand.

Students at Edge HS also mentioned similar issues - that when they were working together in pairs or groups they were able to point out each other's mistakes and thus learn from one another. In addition, EFGI/P5 added that "*we worked faster in pairs*" (line 141). The same student further related that:

> *Well, I don't really like shapes and working with them…but then…and at first I…me and my partner were like failing. Because we were not doing good and when I wanted to stop the thing, she kept me going. …cause if I did not have a partner, I doubt I would have participated. I would have but then I wouldn't have put my full heart into it.* (line 192)

When students worked alongside each other they were able to encourage and motivate one another to complete tasks. As other students put it, they were able to rely on each other for encouragement, assistance & explanation.

Although most students found working in pairs or groups to be helpful, one or two students commented that at times there was a group member who was not working collaboratively, and was simply taking advantage of the other group members. One or two students also remarked that when working in groups some of the group members didn't always listen to the suggestions made by other students. However, in general there was overwhelming support from the students for working collaboratively in pairs or groups since they were able to assist one another and thus work faster.

5.6.3. Autonomy

Hannafin (1984, p. 4) explains that "learner control [or autonomy] is demonstrated in lessons where individuals control the path, pace and/or contingencies of instruction". Autonomy is an important aspect in teaching and learning as it allows a student to "…take charge of his or her own learning" (Linneweber-Lammerskitten et al., 2011, p. 2). There is evidence from research that students in control of their instruction will achieve higher results (Overbaugh, 1994). In these VITALmaths video clip lessons, students described some of the instances of autonomy which in their view helped them greatly to learn. According to EFGI/3, being able to view the video clips on a cell phone in class was useful because:

> *it actually gives you a chance to think and you can read and you can replay the thing. So, sometimes the teacher says something and you're like, I didn't get that and I won't ask her and with the cell phones you can just, okay I'll play that again and see if I get it and then you do that until you get it.* (line 200)

Student DFGI/P4 echoed these remarks by saying:

> *You see the teachers don't always repeat the thing. When you're watching … watching it … you … you can repeat it, repeat it and see what actually was going on.* (line 276)

The students particularly appreciated that they were in control of their learning by holding the means of instruction in their hands. Furthermore, they were happy that there was always an opportunity for them to re-watch the activity in order to grasp the lesson at their own pace. Stemler (1997) explains this observation by saying that

since cell phones are free of the teacher, students take greater control over the learning, thereby promoting independence, satisfaction, and enthusiasm. Hannafin (1984) gives emphasis that some students may learn all the intended information rapidly and never need to branch for review or remediation, while others will want to repeat or rerun a presentation. The environment in these cell phone lessons allowed students to work in a manner that they were able to repeat whatever scene they wanted to comprehend at their own discretion, a contingency which created satisfaction for both faster and slower students. This resonates with Stemler's (1997) notion of learner control to access learners' independence, satisfaction and enthusiasm. To supplement this piece of evidence, it was noticeable that students were able to carry on with the various exercises before or even without the teacher instructing them. This was especially vivid in Ms. Edge's lessons where a worksheet supplemented the use of cell phones.

The overall sensation of the students was that watching and interacting with the dynamic pictures on a cell phone was more than someone telling you what to do. Furthermore, imitating the same experiment as viewed in the video clip encouraged students to engage meaningfully with the contents of the video clip. The VITALmaths video clips are purposefully made from natural materials to allow for more direct and personally meaningful engagement with the content of the video (Linneweber-Lammerskitten et al., 2011). It was evident that this aspect of the video clips supported/promoted student autonomy.

5.6.4. Speeding up of lessons

As explained by Prensky (2001) "today's teachers have to learn to communicate in the language[22] and style of their students. This *doesn't* mean changing the meaning of what is important, or of good thinking skills. But it *does* mean going faster" (p. 4). This resonates with a recurrent theme that emerged during the data analysis process: the use of video clips on cell phones was effective in speeding up lessons. Ms. Edge commented that when she taught in her usual way she found that students were much slower than when she incorporated cell phone video clips into the lesson. She continued to add that the students were much faster in terms of catching up with

[22] By "language", Prensky is also referring to "technology", particularly in relation to "those younger students whose social networking concerns match their obsession with mobile technology" (James, 2011, p. 182)

the lessons when they were using cell phones as compared to what she called her "natural teaching"[23].

Student EFGI/P3 confirmed this observation by remarking that "*we understood things faster than we usually do*" (line 116). She underscored that:

> *…for example, if somebody had to talk and not show us the pictures we were using like that whole triangle thing…and somebody had to say that, I wouldn't have able grasp it as fast as I did when I actually saw it on a cell phone.* (line 118)

Another student (EFGI/P4) supported her remark by saying that cell phones were much better and faster than using a textbook. Another aspect that helped in terms of speeding up the lessons was described by DFGI/P1. He found that when using cell phones "*the teacher didn't have to write everything, write instruction on the board. We just had to watch it in the video. It was also saving us time, so that we can finish everything in time*" (line 272). This suggests that the VITALmaths video clips have the potential to shift the mentality of teaching away from the chalkboard. When the teacher is not glued to the board it increases chances of individual attention and dynamic interaction been the teacher and students.

5.6.5. Affective aspects such as motivation

A strong theme running through the data related to the affective domain of the students' experience. The environment created through the use of cell phones did not only contribute to active participation but also created a space for students to be comfortable and confident. For example, shy students were observed to have been participating far more readily, and were far more enthusiastic than normal. According to Ms. Deep, shy students helped other students to navigate the phones in order to access the video clips. The cell phone context thus gave rise to a space that provided usually shy students with the confidence to participate. This observation was echoed by fellow students who themselves observed that some students, who normally did not want to do anything, took part in the VITALmaths lessons and activities.

[23] Natural teaching refers to Ms. Edge's usual way of teaching – a *chalk-and-talk* approach.

Interestingly, Ms. Edge suggested that the positive atmosphere and enthusiasm generated in the cell phone lessons may well be a result of students' affection and affinity towards cell phones. She noted that when she taught in her usual manner it looked like students took it as if the content was being forced into them from books. However, during the cell phone lessons, that fact that the information was being extracted from cell phones rather than books seemed to motivate students to engage more readily. Ms Edge suggested that students placed their trust in cell phones to such an extent that they were prepared to engage with cell phone content with enthusiasm.

Ms. Deep observed that students were actively involved in the lessons because the activities demanded that students concentrate and observe what is happening in order to be able to implement and apply what they had seen. Students also commented that they were more focused when they used cell phones because there was an embedded demand in the activities. They added that to experiment correctly required that they watched the video carefully in order not to miss anything, since this would otherwise result in them not knowing what was going on. Ms. Deep added that students seemed to be having fun and she thought that the whole experience had helped students to develop a love for mathematics.

Students said that having a cell phone in class was interesting and motivated the whole class. Students also found cell phone lessons very interesting because it was a new or unusual experience to use cell phones in the classroom. For many students this was the first time they had experienced a cell phone being used for anything other than the purposes of entertainment. Student DFGI/P4 stated that "…*it was interesting. Sometimes you get bored when the teacher is… is teaching us on the board so, while we are using the phones, the phones were interesting to us*" (line 278). This was echoed by student EFGI/P3 who remarked that "*during this I didn't get bored*" (line 186).

It was suggested by the students that allowing cell phones in the class would be a positive step forward. "*I think we should use cell phones more often because it encourages people to do their work*" suggested EFGI/P1 (line 235). EFGI/P2 added that "*yah, I think we should use it because it helps me understand more quickly than the teacher telling me*" (line 233). EFGI/P5 in his part concluded by saying: "*I would*

say that to use a cell phone, automatically helps" (line 232). All these remarks show how much enthusiasm and interest was generated by welcoming cell phones into the classroom.

5.6.6. Dynamic visualization and language issues

One of the most important or significant aspects of effective teaching is the content. The content of these lessons was mainly based on the VITALmaths video clips which are produced with a central idea of being striking and visually elegant. The cell phones acted as a vehicle to transport the video clips into the classroom. Visualization, particularly *dynamic* visualization, is a very important cornerstone in "teaching for understanding" in mathematics because it aids the teacher by engaging learners in realistic situations (Makina, 2010).

A strong thread running through the data concerned the advantages afforded by the visuals (pictures) in the phones. Students remarked that the lessons were different: "*apart from being said, we were also shown*" commented EFGI/P5 (line 134). Students greatly appreciated the fact that they were actually able to see how things were done, for example how various geometrical shapes fitted together, as opposed to simply being told. EFGI/P3's remarks below show that it was the dynamic visual element that finally gave meaning to something that he'd been taught algebraically:

> *At first, I was taught that … a^2 plus b^2 gives you c^2 …And, I didn't know that if you take the shape, the triangle, and played around with it, that you'd actually get the square, and the square within that*..(line 158)

Additionally, students found that the VITALmaths video clips were helpful to them as the clips facilitated greater understanding. They singled out the use of pictures in particular as the most helpful element of the video clips as compared to textbooks. This links up with the notion that seeing is better than hearing (Foellinger & Trabasso, 1977). According to DFGI/P4 "*the phone thing really helped us because, when it is shown in the phone, you can see what you want to do, you can see the whole thing*" (line 264). DFGI/P2 emphasised that "*it is more than, just like, someone told you what to do. …it* [is] *very good to see it than like when you explain it*" (line 265). DFGI/P4 reiterated that:

> *…when you are watching something, it's more than you being told, because when someone is telling you something, you don't…you don't*

understand it clearly but when you are seeing it, like in a visual, then it's much helpful… (line 270)

What is amplified in these responses is the positive reception of cell phones in that they allowed students to be able to *see* the mathematics.

An interesting aspect of two of the video clips used in the lessons ("The theorem of Pythagoras" and "Discovering right-angled triangles") is that their text was in German. However, in spite of the German text, students were able to make sense of the video clips and carry out the investigations efficiently. Students credited this achievement to the strong visual imagery in the video clips. It would seem that the dynamic visualization was so strong that the language of the text didn't really matter.

5.6.7. Hands-on activities

According to Ghazarian (2008, p. 2) "hands-on learning, is learning by doing. It involves a child in a learning experience that enhances the child's ability to test, sense, apply and learn". Akinmoladun (2008, as cited in Ghazarian, 2008) remarks that "hands-on learning empowers students." Research indicates that the hands-on approach for teaching is the best way for students to learn (Ewing, 2005, in Ghazarian, 2008). Hands-on activities take place when teachers provide students with materials and resources in order for them to experiment and investigate, collect data, come up with theories and hypotheses, test conjectures, and formulate conclusions. Both Piaget and Vygotsky recognise the need for the concrete, the tangible, the hands-on sensation. As Aristotle (cited in Ghazarian, 2008, p. 3) remarks "what we have to learn to do, we learn by doing".

The practical or hands-on activities were appreciated by all participants as an important feature that contributed to the success of these lessons. Ms. Edge remarked that the VITALmaths video clips revived the practical essence of mathematics. For example, she commented that the cell phone lessons were very practical in that the video clip content required students to use instruments to measure, test and experiment, and thus arrive at their own conclusions. In her own words she said:

> *…what was so fascinating is the core question of practicality. Something that we really need in maths… We need to show them things happening and the VITALmaths was superb when it comes to that.* (line 16)

Another interesting comment made by Ms. Edge was that because their school is under-resourced, cell phones afforded students an opportunity to see everything happening in front of them, and this made the content far more understandable and accessible. This is a core component of the VITALmaths video clips as envisaged by Linneweber-Lammerskitten, et al., (2010) in that "it is anticipated that this innovation will have a significant positive impact for teachers in deep rural settings where access to mathematics resources is very limited" (p. 33).

In addition, Ms. Deep felt that the VITALmaths video clips helped students to concretise the concepts they were trying to learn. She reasoned that the information learnt would be internalised by the students more readily because they had proven and explored the result by doing it themselves, rather than simply being told to memorise the result. She indicated that the approach used with the VITALmaths video clips was completely different to her normal approach of introducing Pythagoras' theorem. Based on her experience, she usually gave students a right-angled triangle and simply informed them that they must know that the side opposite the 90° angle is called the hypotenuse and that the relationship between the sides was expressed by the formulae $a^2 + b^2 = c^2$, which she expected students to memorise. She commented that she never usually gave students a chance to prove it or to do hands-on activities. This resonates with John Locke's comment (as cited in Ghazarian, 2008, p. 2) that knowledge is "acquired by example and practice instead of charging children's memories with rules and principals [*sic*]".

Ms. Deep admitted that practical activities during the lesson contributed immensely to the concentration of the students in her class. In her own words: "*I think those eh, practical eh, activities got them to hands on activities. … engaged them in hands-on activities, they become more involved*" (line 57). Both Ms. Deep and Ms. Edge were of the opinion that students are used to formulas and equations most of the time, and they believed that the VITALmaths video clips had exposed their students to practical hands-on activities, which was very different to what their students usually experienced in the classroom. However, Ms. Deep found the hands-on activities time-consuming. This experience is common for traditional chalk-and-talk teachers

who depend on a rigid curriculum and who teach with a focus on completing work in accordance with the prescribed work schedule.

5.6.8. Teacher enrichment

Linneweber-Lammerskitten et al. (2010) envisage that the VITALmaths video clips would be able to be used for a variety of functions, one of which is for teachers to use them to further their own mathematical conceptualisation and understanding. Ms. Edge remarked that:

> *…what was fascinating with me was that it* [i.e. the VITALmaths video clips] *widened the scope of understanding…my scope of understanding. Because, I am so stereotyped, depending on textbooks knowledge, you get my point, that it sparkled this side of being practical that I could sense as the time goes on, even my…my thinking skill was…was improved. My thinking skill was improved.* (line. 26)

Ms. Deep echoed similar sentiments by relating that in viewing the VITALmaths video clips and imitating the investigations she had also learned something new.

These sentiments echo with the notion that teachers should *themselves* be lifelong learners. As teachers continue to engage with new material and pedagogy, their effectiveness as teachers should expand and grow. VITALmaths video clips would seem to be a potential resource to add to this experience of lifelong learning.

5.7. CONCLUSION

In this chapter I have presented and discussed the data collected in the video observations, interviews and focus group discussions. The data emanating from the interviews was based on the experiences and perceptions of the participating teachers and students. The themes used to categorise and discuss the data gradually emerged from these interviews and video recordings.

As a result of cell phones being banned in schools, teachers and students have turned a blind eye to them as potential educational resources. However, computers (which are perceived as being the primary ICT resource in education) are not always present in schools, and even when they are they are often not made available to the students. Ironically, the majority of students have their own cell phones that could potentially be used as an ICT resource in the classroom.

In terms of the lessons which incorporated VITALmaths video clips, both teachers and students found that cell phones were helpful particularly in that the content could be viewed at the student's convenience. In addition, the VITALmaths video clips were found to be engaging and interesting and that they required students to explore and experiment through hands-on activities in order to build conceptual understanding of mathematical ideas. The cell phone video clips further sparkled students' interest, challenged their thinking and promoted active participation.

An important component of the lessons was the role of the teacher. This aspect, along with other pertinent findings, will be discussed in the following chapter.

CHAPTER 6

FINDINGS & CONCLUSION

> *What can be done to extend the reach of ICT to the unreached? There is an urgency to keep pace with ICT development and its benefits while also addressing possible areas of developmental benefit of ICT to other target groups.*
>
> Boateng (2011, p. 1)

6.1. INTRODUCTION

This study aimed at providing rich and in-depth descriptions of how cell phones can be used in the teaching of Mathematics. In this chapter I summarise keys ideas and research findings. The chapter encompasses a summary of important emerging themes, and highlights the role of both the teacher and the technology (specifically cell phones) within the classroom context. This is followed by a discussion of the limitations of the study, the significance of the study, recommendations and implications stemming from the study, and lastly suggestions for future research.

6.2. SUMMARY OF EMERGING THEMES

During the data analysis process, various themes and common threads gradually emerged. These are summarised here in relation to the theoretical framing of the study, a framing which incorporates constructivism (specifically social constructivism), active learning, interaction, collaboration, visualization, and autonomy. Although each theme is discussed individually, it is acknowledged that they are complementary, interrelated and overlapping.

6.2.1. Participation and engagement

A strong finding running through the responses of both teachers and students is that there was active participation and excellent engagement in the lessons that incorporated cell phones. Teachers indicated that students' concentration was also good, exceeding their expectations. They attributed this to students wanting to take hold of what was being viewed on the cell phone in order to be able to follow and reproduce the activities themselves. Encouragingly, both teachers highlighted that

shy students were in top form and participated outstandingly in all three lessons even to the extent of helping the usually faster students to cope with the technology. In addition, teachers pointed out that students were willing to learn, participate, and share their findings/solutions with the teacher and other students which in turn served as a motivation to other students and provided valuable feedback to the teacher. Overall, there is strong evidence to suggest that cell phones enhanced students' participation.

6.2.2. Collaboration

In terms of collaboration, students greatly appreciated that they were able to share knowledge and ideas when they worked in pairs or groups. They testified that they were able to point out each other's mistakes and thus learn from one another. Students added that they were also able to explain to each other concepts, steps and procedures. Another significant finding emerging from the data is that students who normally feared to ask assistance from the teacher now had an opportunity to ask for help from other students and thus receive assistance. Students specifically pointed out that when they worked alongside each other they were able to encourage and motivate one another to complete tasks, and they were also able to rely on each other for encouragement, assistance and explanation. The study reveals that the use of cell phones in the classroom has the potential to increase collaboration.

6.2.3. Autonomy

The students particularly appreciated that they were in control of their learning by holding the means of instruction in their hands. Furthermore, they were happy that there was always an opportunity for them to re-watch the activity in order to grasp the content at their own pace. The environment in these cell phone lessons thus allowed each student to work at a pace which they felt comfortable with, and which each student had direct control over. This aspect supported both faster and slower students. The overall sensation of the students was that watching and interacting with the dynamic pictures on a cell phone led to an experience that was far more than simply someone telling you what to do. Furthermore, imitating the same experiment as viewed in the video clips encouraged students to engage meaningfully with the content of the video clips. As a result, in those lessons where worksheets

complemented the use of cell phones, students were able to work much faster on their own without the teacher's instructions.

6.2.4. Speeding up of lessons

A recurring piece of evidence that emerged during the data analysis process is that the use of video clips on cell phones in the classroom was effective in speeding up lessons. Teachers pointed out that there was a marked difference when they compared their normal lessons to those in which they incorporated cell phones. They mentioned that students were much faster in terms of keeping up with the content as well as with grasping concepts. Students underscored that when cell phones were incorporated into the lesson, the teacher didn't have to write everything on the chalkboard or explain the instruction. According to students, this aspect saved them time, which led to speedy completion of many tasks.

6.2.5. Affective aspects such as motivation

A solid finding running through the data related to the affective domain of the students' experience. The environment created through the use of cell phones did not only contribute to active participation but also created a space for students to be comfortable and confident. For example, shy students were observed to have been participating far more readily, and were far more enthusiastic than normal. Teachers remarked that the positive environment and enthusiasm may well have been a result of students' affection and almost natural affinity for cell phones. The simple fact that information was being extracted from a cell phone rather than a book seemed to have motivated students to engage more readily.

6.2.6. Dynamic visualization and language

A strong line of evidence running through the data stressed the advantages afforded by the dynamic visuals (pictures) of the video clips viewed on the cell phones. Students greatly appreciated the fact that they were actually able to see how things were done, as opposed to simply being told. An important aspect of using cell phones in the classroom for displaying video clips was that each student was

afforded the opportunity to be able to *see* the mathematics. Another interesting finding was that although two video clips were in German, students were still able to make sense of the strong visual imagery in the video clips and carry out the investigations efficiently. It would seem that the dynamic visualization was so strong that it took precedence over the language of the text.

6.2.7. Hands-on activities

The practical or hands-on nature of the cell phone lessons was highlighted by participants as being an important feature that contributed to the success of these lessons. Teachers particularly appreciated that the VITALmaths video clips exposed students to hands-on activities, which was very different to what their students usually experience in the classroom. The hands-on nature of the lessons was at least in part responsible for keeping students busy, engaged and focused. Students also appreciate that they were able to play with materials in order to investigate and explore scenarios which were normally simply related to them verbally. The study clearly reveals that VITALmaths video clips viewed on cell phones in the classroom has the potential to promote meaningful hands-on engagement.

6.2.8. Teacher enrichment

Teachers divulged that they personally furthered their own mathematical conceptualization and understanding when they engaged with the VITALmaths video clips. These sentiments echo with the notion that teachers should *themselves* be lifelong learners. As teachers continue to engage with new material and pedagogy, their effectiveness as teachers should expand and grow. VITALmaths video clips are a valuable resource to add to this experience of lifelong learning by affording teachers the opportunity to improve their mathematical content knowledge as well as their pedagogical content knowledge.

6.3. THE ROLE OF THE TEACHER

As with most pedagogic approaches and technologies used in education, the teacher's role during the lessons with cell phones was crucial. The teacher had the responsibility for choosing and sequencing the material to be performed (the curricular activities), and guiding the lesson in the desired direction. More specifically, the teacher was responsible for proper planning, familiarization with the video clips, connecting the lesson to previous concepts, pacing students' activities in class, and giving and directing attention towards the students who needed the most encouragement while keeping the overall performance moving forward. Having VITALmaths video clips and cell phones as resources in the classroom does not immediately solve all the problems inherent in an under-resourced classroom, or indeed any classroom. However, the study did find that that the use of cell phones and the VITALmaths video clips strongly supported the pedagogical endeavour by freeing up time normally spent on lesson delivery, thereby enabling teachers to attend more easily and more often to individual students or small groups rather than addressing the class as a whole.

The two teachers involved in this study highlighted, through their actions in the classroom, various roles of the teacher in these lessons: affording students an opportunity to learn; scaffolding (supporting those who are struggling); interacting with students to determine the level of learning; encouragement; challenging students' thinking by posing questions to make them realise the way forward by themselves; showing flexibility in terms of unexpected student responses; and checking that all students are participating in the lesson.

In terms of the role of the teacher, the study highlighted the importance of teachers being familiar with the cell phones and having a thorough understanding of the VITALmaths video clips in order to be able guide, assess and direct the learning. In addition, using carefully prepared worksheets in conjunction with the video clips was revealed to be an effective means of promoting student autonomy in that it allowed students to carry on the learning process at their own pace and with minimal instruction from the teacher.

6.4. THE ROLE OF TECHNOLOGY

The use of mobile technology in education is a recent wave due to the ever presence and rapid advancement of mobile devices such as smart phones, PDAs, and handheld computers. The research findings presented in this thesis have shown some of the benefits of using mobile technology in learning. A substantial finding in this study shows that technology is able to act as a catalyst for a significant and powerful shift in the dynamics of the classroom environment and the resultant pedagogy and learning that takes place. This resonates with Prensky's (2008) remark that "the role of technology in our classrooms is to support the new teaching paradigm…. to support students teaching themselves (with, of course, their teachers' guidance.)" (p. 1). The technology of the cell phone has the potential to provide students with a variety of new, highly effective tools that they can use to learn on their own and at their own pace, i.e. autonomously. Furthermore, cell phones represent a medium of technology that students are comfortable with in terms of their out-of-school experience, and that they have control and ownership over.

6.5. LIMITATIONS

Despite their potential for richly textured data, case studies nonetheless have their limitations. The findings of this case study are not generalizable due to the small number of participants involved in the research. However, findings could be increasingly refined through further research en route to a broader understanding of the research question.

6.6. SIGNIFICANCE OF THE STUDY

This study contributes to contemporary teaching strategies by boosting teachers' repertoire of pedagogical practices, specifically the use of VITALmaths video clips and the use of cell phone technology in the classroom setting. It is also hoped that through this research students and teachers will be inspired to make use of the freely available databank of VITALmaths video clips, not only in the classroom setting but also in non-traditional learning spaces where having instant access to the video clips will enable them to take advantage of the spontaneity of a given moment. Furthermore, this research study provided valuable feedback to the VITALmaths project in terms of the efficacy of their video clips.

6.7. RECOMMENDATIONS AND IMPLICATIONS

Considering that mobile technology, in particular the use of cell phones, is only an emerging approach to classroom pedagogy, as prompted by the pervasiveness of both cell phones themselves as well as cell phone signal coverage, this study showed that cell phones represent a viable alternative to more conventional forms of ICT in under-resourced schools. This is significant since in most township or rural schools there are still insufficient computers and associated infrastructure for each student to experience authentic learning through ICT. Furthermore, teachers in such under-resourced circumstances struggle to access contemporary learning materials. Based on the experiences of this study, I would therefore like to recommend the following:

- Teachers should be encouraged to accept and use cell phones as hot spots of readily accessible information, e.g. through the internet as well as shared resources.
- The use of mobile learning in under-resourced schools, particularly in the GET and FET phases, should be promoted. In order to minimise the potential costs incurred by the students in terms of data transfer, items can be downloaded onto a PC and synchronised to mobiles, or alternatively these can be shared through Bluetooth and other mobile settings.
- School rules should be relaxed in order to allow students to make use of cell phones in appropriate classroom settings. The relaxation of school rules pertaining to cell phones will also facilitate a programme whereby students could be educated on how they could use their “number one tool” to retrieve educational information and also how to filter and make use of it. Most students see their cell phone as a preferred mode of communication, and by embracing the cell phone in the school context, Prensky (2005, p. 6) asserts that “instead of wasting our energy fighting their preferred delivery system, we will be working to ensure that our students extract maximum understanding and benefit from the vast amounts of cell-phone-based learning.”
- Educators need to be convinced that mobile learning is effective and will benefit them in the delivery of instruction. I therefore recommend that the successful use of mobile technology as described in this study should be communicated to the broader fraternity of educators.
- Finally, I encourage an increase in the production of the VITALmaths video clips since they were found to be highly useful in the teaching of Mathematics.

Despite the potential positive benefits of mobile technology in the classroom, there are nonetheless unanswered questions relating to the health risks associated with prolonged mobile phone usage. In addition, many researchers have also emphasized the potential social and psychological problems that have been linked to excessive cell phone use among youngsters (Ahmed & Qazi, 2011). Furthermore, although we experienced a fantastic learning environment with cell phones in the classroom during this study, there are nonetheless scenarios that need careful consideration, for example cyber-bullying, irresponsible use by students, criminal activities such as theft. However, mobile learning initiatives are all about change management, and change management is about dealing with people (Belshaw, 2010).

Another important point to keep in mind is that cell phone technology and associated resources such as the VITALmaths video clips should not be seen as ends in themselves. Rather, they are teaching and learning resources that still require the artistry of a competent teacher. They should thus be related to other learning tools that students and teachers are already using, and/or tools that have arisen from technological advancements.

6.8. FUTURE RESEARCH

The study reported here was carried out in two township schools. Although it has yielded intriguing findings, it would be interesting to extend the study in the future to deep rural schools where the provision of resources is even more problematic.

Mobile technologies have been found to support learning experiences that are active, highly engaging, collaborative, accessible, and enriching in the classroom. However, there is a need to carry out similar research on how the inherent mobility of mobile technology can allow teaching and learning to extend to spaces beyond the traditional classroom.

Finally, this study focused specifically on aspects of *teaching* with mobile phones. Although it is difficult to separate teaching from learning, it would be interesting to conduct a similar research project which focused specifically on aspects of the

learning process as supported by the utilisation of mobile phones in the classroom context.

6.9. CONCLUDING COMMENTS

Mobile learning may be the next big evolution in education. It promises vast potential as an instructional aid to promote active interaction and collaborative learning, to engage students with both content and context, as an alternative to books or computers, and in situations where students might be geographically dispersed. The use of mobile learning, specifically the use of cell phones, has the potential to contribute to contemporary teaching strategies and represents a cheap and readily available resource which is a viable alternative for under-resourced schools.

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Appendix A: Ms. Edge's interview transcript

Transcript: Ms. Edge's interview **School:** Edge HS

Line No.	Speaker (s)	Conversation
After the greeting and setting a rapport for the participant, the interview started NB: Steve is the interviewer and Ms. Edge (*not real name*) is the Interviewee, a teacher at Edge HS		
1.	Steve	Uhm, I've got about seven set questions but a lot more questions might be developed in our discussion. Uhm, let's start with the first one I've prepared here: Based on your experience, Madam, how would you describe teaching with cell phones in general?
2.	Ms. Edge	Okay, Steve, when I started this I was so skeptical first, because of the rule of the school that no cell phones are allowed and I was fearing the situation that we might during the process lose one of your cell phones because I know the kids today are so, so, so attracted to cell phones but Thank you my Lord that such a thing never happened in my class until we have finished our…our project. Now, if I can come to our question itself, eh…what I have noted is that, when I'm teaching my learners, they are slower than when they are being taught by the cell phones…
3.	Steve	Okay…excuse me, I'm just going to close this door 'cause there's too much light, I noticed. Yes, uhm… let's just continue there, please?
4.	Ms. Edge	B…b…but unless, if I compare my lessons, my, my, my ordinary lessons versus this VITALmaths videos, my…my kids were…sort of…very fast, in terms of catching up with the lessons when they were using the cell phones than when I am using my natural teaching in…in…in the classroom. Uh, maybe that is because that, you know, the…th…th…the youth generation of today. It…it's so well vest when it comes to cell phones and that is the technology th…that th…th…they envisage most en and as such…they are…they are…they put their trust into that devise in so much that whatever is given back to them through cell phones, i…i…it's received with enthusiasm, because that is not portrayed in this classroom. Because, most of the time I would fear a situation that; "yoh, are they going to follow this?", but you'll find that they follow it easily. Look for instance these two last lessons, they were in German and I was afraid that; "eh, I wonder if my kids are going to grasp this?" To my surprise, everything was superb. And I was tempted to…to ask; yoh, can't…can't Rhodes think of assisting our schools, in terms of teaching using cell phones.
5.	Steve	I don't know…based on these findings and..and…and writings and motivations and recommendation…well, it's an area that needs to be…to be tapped in to.

6.	Ms. Edge	Yah, explored.
7.	Steve	Yah, it needs to be explored…yah and then we, we need to get research information that then guides the implementation, otherwise we might not move too fast.
8.	Ms. Edge	Okay.
9.	Steve	Yah, I want you to be a bit specific now, uhm, can you explain specifically how the utilization of cell phones impacted on your teaching in general, and then, on the teaching of Pythagoras. Maybe we should start first with, not repeating what you've said earlier, but in…in…in general; what impact did you notice in your teaching with cell phones?
10.	Ms. Edge	Besides this thing of my kids being faster when I am teaching them natural?
11.	Steve	Yah. Let's…you can incorporate that as well.
12.	Ms. Edge	Yah, they were so fast, to grasp the concepts easily, to…I don't know if they're being exposed to the practical side of it, that's what made them to be so…easily teachable. Maybe I'd also commend the practical side of it, rather than improvising, you know, the situtation of our schools, we don't have the resources but, seeing everything happening in front of them and make them to be easy to understand…as compared to.. to our improvisation.
13.	Steve	Now, with the Pythagoras theorem? How different is it to other approaches?
14.	Ms. Edge	Now, the…the…if you can take the theorem of Pythagoras, the way it is taught, i…i…in our cell phones, it is too practical and now they become…they believe it, easily. But when I just teach it, you'll see them sit there; they don't look at you as if you are formulating this yourself. But, you…you could see when Amalia (*not real name*) was doing the lesson of today, she measured everything using a ruler. And then, she then believed that; okay, when Pythagoras is saying the square on the hypotenus is equal to the sum of the squares on the other side, it is…it is real. She thought first, you could see she was like "I don't understand, I don't understand" and in such time I said to her "mmm…take your ruler and measure it out". When she measured it out and she came to the chalk board and she do it there, and then she was the first one to say "okay". So, within the…th…the lesson, I was getting the "okay's" the "okay's" that shows that "now I believe". So, i…it gave me the implication that, all along, as I'm teaching, they take it as if it is being forced into them by books. But, when we used the cell phones they saw that *chini*, this is reality. Because now I was getting the…the…the signs that I never got in my class, "okay", "heeeeey", all those things. And you could see that they didn't want to part with this project. When we said you wanted to be left with the six for the interviews, the rest were still sitting, because they didn't want to, yet, I couldn't do otherwise. Because, those six volunteered themselves.
15.	Steve	Okay, uhm, let's just continue with the next one; What did you find useful or unhelpful about the VITALmaths video clips

		and the cell phones, all together?
16.	Ms. Edge	What…what…what was so fascinating is the core question of practicality. Something that we really need in maths. We can't theorize when it comes to maths. We need to show them things happening and the VITALmaths was superb when it comes to that.
17.	Steve	Okay, uhm, is there anything that you find a little bit complicated? Unhelpful?
18.	Ms. Edge	Not toward the end. At the beginning I was afraid that there would be in German use but when I was in that lesson, I didn't even feel any pain when it comes to the foreign language that is there. So, to me it says; maths is the same across the languages. And it's useful when it is practical.
19.	Steve	Thank you very much. Uhm, what was the nature of learners' participation when working with cell phones, compared to usual classroom (not clear)?
20.	Ms. Edge	Yoh, I…I…I saw something that I never saw in my class; everybody participated. I usually get shy learners in my classroom who don't want to talk, I usually get learners who uh, hide behind the other learners, but when I was using this cell phone thing, everybody was participating. To me it says it sparkle their interest. And, I think, I have changed my style of teaching. I've changed it. I don't want to lie to you, I'll be that busy teaching everything, every models, whatever (not clear), because I saw the part that is lacking for my kids; to see maths and to do maths.
21.	Steve	Okay, uhm, I…I've noticed, that learner wasn't here today. Uhm that fat learner who normally sits second from the back next to…the one…lady was sick one day. How is her…. her participation in other lessons? She was a little bit in…but not in? in but not in?
22.	Ms. Edge	Okay, the problem with Aune (*not real name*), is that, eh, I don't know whether she was ready for this class. You know, this class 10F is Mathematics and Physical Science class, and it demands a lot of sacrifice and, eh, when you look at Aune, to me, Aune to me, she lacks some training whatever, in terms of this class. Because, when I checked with the Physical Science part of it, she's just the same way as she is in Maths class. With Maths class, she lacks the ability to do the basic numerical, uh, operations. Those four basic operations; she…she…she can't add, she can't subtract, multiply, can't divide, then when I checked with the ex-teacher, how was she when it comes to maths, you would find that the teacher said, eh, she didn't even know the class because she was new to the subject and she never majored in the subject and she was just given the subject to teach. So that is why you've seen it that, this year…I make a point that whatever help I can get, I utilize it with I've got Wednesday classes but are given with by Rhodes, your RFR, then you've got ehm, Saturday classes that we are getting from Rhodes partnership, your community engagement, then I'm having also afternoon classes with them. Now you'll find this, this very same student…learner we are talking about, she's not attending those classes. So you could see that…that she is not ready for this class. Maybe she can make it for another class, but

		not the maths and physical science class. And, with other subjects, she's also not…she's average.
23.	Steve	Okay.
24.	Ms. Edge	Subjects like your languages and they are also doing the Geography. She's average in Geography as well. So all the science subjects are not there for her.
25.	Steve	Okay, let's discuss the Mathematic and VITALmaths video clips; How relevant did you find it to Grade ten and what did you find resonating very well with you as a teacher?
26.	Ms. Edge	Okay, it is so relevant to Grade ten because taking into cognisance the..the…the requirements of our curriculum, because Pythagoras is, within, this depleted curriculum and uh…what was fascinating with me was that it widened the scope of understanding…my scope of understanding. Because, I am so stereotyped, depending on textbooks knowledge, you get my point, that it sparkled this side of being practical that I could sense as the time goes on, even my…my thinking skill was…was improved. My thinking skill was improved. If you take, for instance, is this…this Pythagorean triples, uhm, when I sense that "okay, this is the tread that we should follow" but some time ago I was teaching patterns, I wasn't as fast as I was in this lesson. And you can see that is the…almost one and the same thing. Then I saw that "okay, this thing improved my thinking skills".
27.	Steve	Okay, uhm, I want to find out, if you can describe for me an entire lesson; what strategies did you find appropriate in the incorp…incorporation of the cell phones? Like, if you can describe for me the whole lesson, say, if I have a lesson and I have cell phones incorporated, this will be the flow of the activities.
28.	Ms. Edge	So, if I've got a cell phone and I plan my lessons, then I'll allocate a certain time to…to just familiarizing themselves with what is happening within the lesson itself. So, by so doing, they are also training their eye and mind coordination. Now, having done that, you then do the recall, you see? They say out what they were watching from the cell phones, and then out of that, then you put in some exercises to check if what they've managed to see and what they are saying, if they have managed to…to see from the cell phones, did they grasp anything out of it, by..by…by giving them the exercise to that effect. And exactly, what…what maths really wants. Because, if you cannot test them by giving exercise, then they might as well say, this is not very, very, very objective or fulfilling the objective.
29.	Steve	Uhm, what would you say about the home works and the way they have completed class activities…is…is there any connection between "what I have done in class, and what I have done at home?"
30.	Ms. Edge	I…I don't want to lie with you, Steve. You see, (not clear), the way they were eager to submit, I was saying to myself, I'd rather leave this class to you, because I am struggling to get the feedback when it comes to home works, especially home works. I let alone the class work that is done in

		class. They would take longer time so that the bell ring and then they are free of me. But this time around, you give them a piece of work to do, they are all there and each one wants to respond, and I said “Hey, I would ask Rhodes to assist here”. I’m sure they were so excited to be taught on the devise they like most. So, the person who thought of teaching using a cell phone…yoh-yoh…that one… has done us a great deal. I so wish that it can be followed up and be concluded.
31.	Steve	Uhm, towards the end, I want to find out if you have any other comment about the experience, using the VITALmaths video clips and cell phones in the classrooms?
32.	Ms. Edge	The…the…the comment that would be is, as you know technology…now cell phones are a way from me, and away for my kids, is there is not going to be a drop back again, and we are not going to go back to our steady way of doing things. That’s my main one.
33.	Steve	Any other comment about cell phones and (not clear)?
34.	Ms. Edge	No, except that I envy it. They are doing a mammoth task…to alleviate even stress. They alleviate stress in class, because you know as a teacher, when you stand in front of your kids, you’ve got this thing in you that is “oh,…oh I wish I could take my lesson across” so you’ve got that stress, but with this cell phones you could see that, every beginning of the lesson you see that all the lesson was there to help. They show their…their interest. At every beginning of the lesson. Sometimes you get frustrated when you look at them looking at you like this, as you are reading your concept to them, as if they know nothing about what you saying. It really frustrates me.
35.	Steve	Okay…did I cut you?
36.	Ms. Edge	No.
37.	Steve	Okay, thank you very much, Ms.Edge that was the end of our interview…

Appendix B: Ms. Deep's interview transcript

Transcript: Ms. Deep's interview **School:** Deep HS

Line No.	Speaker (s)	Conversation
After the greetings and setting a rapport for the participant, the interview commenced.		
38.	Steve	Firstly, I'd like to thank you very much for…for your support. Particularly that you came out and volunteered to help us in this study. I'm very, very thankful uhm, for your time, for your preparation, all this activities you have prepared for your learners. I'm…I'm really thankful. Maybe I don't have words to thank you right now. I must think about it again. We are going to do a short interview where we are going to talk about uhm…these cell phones in…in your classroom. Your experience, what you think you can recommend for the future, if the possibility might open up or what we need to look at to make these cell phones more eh,…effective in the classrooms. I've put seven questions, but please allow me also to ask some follow up questions, just to get clarity on issues that you might raise. If we can start with the first question, is; based on your experience, from the beginning of these cell phones towards the end that…of the lesson today, how would you describe teaching with cell phones in general?
39.	Ms. Deep	Okay, first of all, eh…it makes…it makes learners eh…to be…eh…actively involved in the lesson. Eh, also, it make them…concen…concentration because they have to look, observe…they're develop skills where they have to observe what is happening so that they can implement or apply what they have seen.... mhmm.... And also to do…to expose on those hands-on activities…because they have used to formulas, so…At least it is fun, so fun, they're also doing fun. It can help them to have ilove in Mathematics.
40.	Steve	Okay. Uhm, can we talk about specific issues like, uhm, can you explain specifically how the utilization of cell phones impacted your teaching in general and the teaching of Pythagoras Theorem? Maybe we can first talk about, what impact did it make on your teaching, using these cell phones in your class?
41.	Ms. Deep	Like, eh…it taps ilearners now, they have the insights of what they are learning. Before they just, eh…they were just saying "x square plus y square is equal to, a square plus b square is equal c^2" so they didn't know that you can prove that end, eh… the impact that would make, is that…eh…the information that they have learnt, last a longer because, we have…eh…

42.	Steve	Why do you think does it last longer?
43.	Ms. Deep	'Cause they proved, they were not told. Or, what they have told, they already have…they proved that it is correct.
44.	Steve	And, in terms of teaching the Pythagoras Theorem? The approach that we normally use to teach Pythagoras, and the approach of the cell phones, or the video clips of the cell phones…how…how would you describe that?
45.	Ms. Deep	To be…to be specific…if I can base it according to my teaching experience, the approach to me is totally different, because I…I…I use just to give them the triangle, I told them that if it's a right angle triangle, then they must know, they that side…side to side is ninety degrees is a hypotenuse, and a square plus b square is c square, so I didn't give them that chance…eh…to prove it and do the hands-on activities. Though, it's…it's…it's helpful but though it's…it's…time consuming.
46.	Steve	I've seen that we have, in a way, a time of overloaded our lessons, doing two videos in one class or one video, and so on but do you think if…if there's any chance that we can make in terms of…of the load in the class, do you think it can change anything in terms of time?
47.	Ms. Deep	Yes, if they can have enough time. Maybe we can give them one activity at a time.
48.	Steve	Okay, uhm, let's…let's move to the next question which is; What did you find either useful or…or unhelpful about VITALmaths video clips and the cell phone all together?
49.	Ms. Deep	No, I think it was useful.
50.	Steve	Okay, how useful was it?
51.	Ms. Deep	As I've, eh…earlier on told you that the information that they have, they got will take a long time…what have that time to observe, and they have applied…the…what they have seen from the cell phone and they have that time that eh… opportunity to work with their friends, teamwork. I think I…it's eh…what have you…what you have done by yourself…it…it's, I can say, eh, what we have done is much better than what we have told.
52.	Steve	Okay, what was the nature of the learners' participation when working with cell phones, compared to the usual classroom settings?
53.	Ms. Deep	I, I know…at least they were free to talk. They were talking and they…they were enjoying it. Even everyone, those, even those I use to ask them to come to the board and do some work…and those, those who are shy, it's very rare to see them on the board, but when they were using the cell phone, everyone was busy, excited, doing…even, I was so

		surprised, even those who are shy, were those who were helping others…
54.	Steve	Serious?
55.	Ms. Deep	Yah, like how to…how to come in the program, how, they…they…they, they are…they were the ones to show them how to come in, to go to the programs, you know? Others were struggling at first to go to the program, how to go to that…to follow the procedure of how to switch their phones.
56.	Steve	If…if I may ask in that…in that uhm, instance, what do you think has really caused the learners to be interested, excited…in your own views?
57.	Ms. Deep	I think those eh, practical eh, activities …got the other (not clear) to hands-on activities. Engaged them, when work…engaged them in hands-on activities, they become more involved.
58.	Steve	Okay, uhm, let us come discuss the mathematics of the VITALmathss video clips; How relevant is to Grade ten and what did you find resonate well with you as a teacher?
59.	Ms. Deep	Come again?
60.	Steve	The…the mathematics in the video clips, how relevant was it to Grade ten, and what did you find resonating very well with you as a teacher?
61.	Ms. Deep	Okay, I think it's…this work we were doing is eh…it's in Grade eight work, but one thing I…I've noticed is that they even struggled, though they are in Grade ten, neh? But so, to me it helped them a lot because they have, eh…meaning that there was a gap, so I think this eh…lesson has helped them to fill that gap. I don't know if that answers the question?
62.	Steve	No, no, you are. But, uhm, I want to find out that the materials and the mathematic that we have the…do you think, despite the fact that there was a gap in the previous lessons, in the previous grades, but how relevant is it to Grade ten? How much useful are they going to use the Pythagoras Theorem, for example, in Grade ten?
63.	Ms. Deep	No, in Grade ten there is no Pythagoras Theorem, but it's…if they are going far and far in Mathematics, then…use….because they are doing Trigonometry
64.	Steve	Oh…okay.
65.	Ms. Deep	In fact, this Pythagoras Theorem was in Trigonometry, so in Trigonometry, they don't prove…because they think I have assume them, they are assume that they have done it…it prove, in those lower grades.

66.	Steve	Now, the mathematics, the video clips and…and so on, what did you find personally interesting?
67.	Ms. Deep	Yes, I've…
68.	Steve	Wha…what, what did you find interesting on the video clips?
69.	Ms. Deep	First of all, when they proving, eh…that it's sum of angles in a triangle, those somethings in the triangle that, or, they were…these triangles, not the first ones where they prove…the first ones…?
70.	Steve	Yah, the first ones, Alex's one and Ben's one
71.	Ms. Deep	Okay, those first ones…okay, one thing I…is…is that eh…is, some of their…in the first ones we have, we taught that eh, this is the theorem, this is theorem, though, it's not eh…Theorem so, we have learnt that eh…sometimes, eh, in order for, in order for eh…theorem or…to be true, it must be true in all, general. It must apply it in all instances, not only for a specific…eh…things.
72.	Steve	Set of measurements..
73.	Ms. Deep	Yah, like events and also…it in the first one…was (not clear). So they have learnt that they must know, they must do a general rule, you know?
74.	Steve	Yah, no I agree with you. Uhm, let me move to the next question; Which strategy did you find appropriate to the incorporation of cell phones? I mean, if you can describe the whole lesson…how…how is it appropriate? Where do you put in cell phone and where is it not appropriate?
75.	Ms. Deep	Okay, I think first of all you have to…before you give them these cell phones to do, you have to give them background of what is going to be done and then after, then, after that, apply the cell phone. And then give them a chance to observe and see what is going on and then implement what they have done. And also, after they have done, though…everything, hands-on, they come up and tell me what did they learn. And reflection in this rule, they should reflect what they have learnt.
76.	Steve	Okay, uhm, when…when we have done this with you from the beginning to the…lesson, today did you find your learners reflecting on that? That, "today we have learned so much"?
77.	Ms. Deep	Not…not always. Sometimes they were, sometimes…or sometimes, I even ask them, even when you are not around, and then I ask them, "did you enjoy that lesson? What did you learn?"
78.	Steve	Yah, exactly. And are they able to come out and say…

79.	Ms. Deep	Yah, it's where I found that they…the gap because I only find…get this learners in Grade tens. I didn't teach them Grade eight and Grade nine, so some of them told me "no we have things to ask, you know that eh…we have to prove" that's why they were struggling most of the time.
80.	Steve	Oh, okay. Probably, the last question, Ms. Deep, is; What other comments do you have about your experiences with our VITALmaths video clips and the cell phones in the classrooms? What other comments…what would you advise, what would you like us to look at? Shortfalls? And…and so on…on using VITALmaths video clips and the cell phones in the classroom?
81.	Ms. Deep	I think, eh… since these learners now agree now one has cell phones and they liked this thing of using the cell phone, I think we can come up with other topics. It's very good. Not only Pythagoras, bring us another like, graphs.
82.	Steve	Okay?
83.	Ms. Deep	Equations, maybe…those will help them. Especially graphs. Because it helps them, my learners, when they are also involved. When they are involved in the lesson, they participate more than when you are, eh…in front of them.
84.	Steve	Uhm, what…what can you tell me about the length of the video clips? You see, these video clips are div…there are five, but each one has got its' length of time. That length of time of video clips and the teaching, how are two relates? What is your comment on that?
85.	Ms. Deep	I think it's, the length of times is too little, they have to rewind, rewind, rewind, and it's too fast. So if they can take time, and take a longer time and not fast, use some time…you know?
86.	Steve	Okay, I don't want to close out anything. Any other comment that you would like to make?
87.	Ms. Deep	I hope that eh…as you have come here with the cell phones, maybe my learners have that hope that eh…in future that Rhodes will sponsor us with cell phones, so that we can do programs, like…you know?
88.	Steve	Yah.
89.	Ms. Deep	And also, I think, I don't know whether if…if Rhodes can also organize workshops for teachers on the use of these cell phones. Because we are not exposed to these things. It is my first time to experience this.
90.	Steve	Yah, we want to do this more research and more research, and then I think that we have ground and when we go out to do a workshop, we know what works and we have to be very careful with (not clear) and all

		these type of things. So I think a…a research like this one is a step into that direction. So, this findings, all this, your comments that you are saying, will then feature into the developing a program that we can roll out for teachers. That…that's my expectations. But, when we are writing, then we inform the University so that our teachers are saying, especially now that they have taken part in this study right now. Otherwise in the absence of any other comments, Ms. Deep, I thank you very much, once again for your time to answer the interview questions, for your time to allow us to come into your practice, into your sensitive classroom and then, for also, you know, for interfering with your work schedules, we might have cost a few delays there. So thank you very much for everything…
91.	Ms. Deep	I would also like to thank you for your eh…presence, because my learners have learnt something.

Appendix C: Edge HS students' focus group discussion transcript

Transcript: Learners' focus group discussion **School:** Edge HS

Line No.	Speaker (s)	Conversation
After the greetings , setting a rapport with the participants, and assuring confidentiality, the interview started		
92.	Steve	okay, thank you very much guys for volunteering to take part in this interview. We'll make it at short as possible, but uhm, I've got a set of…I've got seven questions that I'm gonna ask, but within those seven questions, I'm also gonna make follow up questions on what you're gonna say. Okay? Uhm, let's start with the first question; Who own a cell phone, amongst this group of six learners I have here? Who owns a cell phone?
93.	Group	(All learners raise their hands)
94.	Steve	All of you own cell phones? Okay, so what does…I mean, what do you do? What do you uses that cell phone for?
95.		(Talking softly – not clear)
96.	Steve	Okay, speak a bit loud?
97.	EFGI/P5	Receiving and making calls, social networking, SMS'ing, for…as alarms…
98.	EFGI/P4	Mxit…
99.	Steve	Uh-huh, Mxit…
100.	EFGI/P3	And Facebook.
101.	Steve	Yah, Mxit and Facebook might be included in social networking, but it's good that you mention them. Anything else?
102.	EFGI/P 5	For reminders.
103.	EFGI/P3	Yah.
104.	EFGI/P 5	When you want to check the time and to listen to music. Watching videos, taking pictures…
105.	Steve	(Indistinct)? On your cell phone?
106.	EFGI/P5	Yes.
107.	Steve	Okay…
108.	EFGI/P3	Email people…
109.	Steve	Is that it?
110.	EFGI/P4	Sending and receiving emails.
111.	Steve	Emails!
112.	EFGI/P5	And playing games.
113.	Steve	Hey?
114.	EFGI/P5	Playing games.
115.	Steve	Okay. Anything else that we haven't mentioned? If you remember later on, just let me know, at that question, if something else comes to mind. Okay, let's come back to what we are doing in the classroom.

		What did you find fascinating or different when you used cell phones in the classroom?
116.	EFGI/P3	We understood things faster than you usually do.
117.	Steve	Okay, just elaborate on that one.
118.	EFGI/P3	Uhm, for example, if somebody had to talk and not show us the pictures we were using like that whole triangle thing…and somebody had to say that, I wouldn't have able grasp it as fast as I did when I actually saw it on a cell phone.
119.	EFGI/P5	And it's much better than looking at a text book.
120.	EFGI/P3	Yah, it is.
121.	Steve	Anything else that you've found fascinating? That you've found good? Or maybe different, that was a bit difficult for you to follow?
122.	EFGI/P6	The one in German
123.	EFGI/P4	Yah!
124.	EFGI/P6	It was different than with the use pictures, we all managed
125.	Steve	Okay, in what way do you think did the VITALmaths video clip facilitated your learning? Now, when you're watching this video clips, what did you find helpful…yah?
126.	EFGI/P4	(Speaking very soft – unclear)
127.	Steve	Give me an example of what you say. Say for example, when you were doing what-what, this was much clearer to me. Give me examples of what you found helpful.
128.	EFGI/P2	The sum of two squares…
129.	EFGI/P1	The sum of two squares.
130.	EFGI/P2	Yah.
131.	Steve	So, how was it helpful?
132.	EFGI/P3	You could actually see that the sum of two squares was this, this and that… (Indistinct) tells you. And the sum of this is this makes that…and you could actually see that it fit together and form something than, every (Indistinct) in your mind.
133.	Steve	Yah, any other experience?
134.	EFGI/P5	Many of the…actually, I was never taught that the sum of two squares that we…it would be like said, so it was different…very different, apart from being said, we were showed.
135.	Steve	Who else want to add? I mean, uhm, tell me, do you want to say, uhm, when you see something like how…as your…I mean, like when you were looking at this video, imagine now that there was no video, what would have happened? And then, how could that have influenced your learning?
136.	EFGI/P1	I think we wouldn't understand.
137.	Steve	What else? Okay, let's move on. When you've worked with others in the classroom, what did you find helpful or troublesome? I remember you…I mean all the way you were working in pairs…today I've seen a bit of a large group where three people were working together, but all and all, when you've got these cell phones and you're working with others, what did you find helpful?

		And…or maybe troublesome?
138.	EFGI/P3	What was helpful was…me, I was doing my thing and then, I measured it wrong or I used the wrong ratio, and somebody else did it properly, and then they showed me the mistake I made and vice versa.
139.	EFGI/P5	Yah, and we did things faster in pairs…
140.	Steve	Could you repeat that for me?
141.	EFGI/P5	We worked faster in pairs.
142.	Steve	Uhm..... Were there some trouble, when working with others?
143.	Group	Yes
144.	Steve	Yes? What are they?
145.	EFGI/P 6	Cutting…cutting and pasting…(not clear)
146.	Steve	Do you think the other person was…
147.	EFGI/P6	Yah…
148.	Steve	What? I mean…
149.	EFGI/P6	The other one was boring, the other one (not clear)
150.	EFGI/P1	(not clear)
151.	Steve	What about her?
152.	EFGI/P1	Okay, if somebody made some mistake then (not clear)…and shout at you.
153.	Steve	Oh, okay, okay, I like that. Okay….so what else…did you find troublesome when you worked in pairs or in groups?
154.	EFGI/P3	You wanted to do something like, for example, somebody else would color in their own way and you didn't want them to color in that way and then (not clear), or sometimes you just wanna take over.
155.	Steve	Okay…thank you. Uhm, I know that the Pythagoras theorem was introduced to you before, I mean, maybe in Grade eight, maybe in Grade nine…I don't know, uhm…Grade six?
156.	EFGI/P5	Yes.
157.	Steve	Wow, that's much earlier! So, nevertheless, I want you now to compare for me the approach that was given to you when this Pythagoras theorem was introduced to you, and what you have done now with the cell phones. So I want you to compare, give me the difference that you have seen, tell me what was interesting in that approach and what you find interesting in this approach, and all together, you see? So if you can just got back a little bit in your mind and remember how it was first taught to you and then what you have done now, and then give me how the two are different, or you find them similar. Okay, can you do that?
158.	EFGI/P3	At first, I was taught that, okay, a squared…and, a square plus b square gives you c square and then the square of c, squared as the answer to the other side. And, I didn't know that if you take the shape, the triangle, and played around with it, that you'd actually get the square, and the square within that… that prove that it was actually brought together, and I was taught.
159.	Steve	Uh-huh, does everyone tell from experience?
160.	EFGI/P5	I think it was more fun when we cut and paste (not clear), because when I

		was first taught the Pythagoras, it was just calculating and we never cut and paste the shape and colour in, so it was more fun.
161.	Steve	How was it introduced to you? How was…how where you taught the Pythagoras theorem? Look, there might be similar things, okay? So, you can tell me about that as well.
162.	EFGI/P2	I think this time it's more quicker to understand than last time, like when we had no phones.
163.	Steve	Uhm-mmm? Just go back and remember what was done, and then you compare the two for me.
164.	EFGI/P1	It was more interesting to see a guideline…, a picture in the phone.
165.	Steve	Uhm-mmm?
166.	EFGI/P3	And I didn't know that they call the numbers that you use for Pythagoras, are called Pythas...., I forgot what it's called but then…triples, yah. I didn't know that
167.	Steve	You can call them Pythagoras triplets…they call them Pythagoreans triplets.
168.	EFGI/P3	Yah, I didn't know that so I learnt something new.
169.	Steve	Tell me experience, did you?
170.	EFGI/P6	Yah, I'm still trying.
171.	Steve	Okay, (not clear), okay. Okay, uhm… Let's talk about the nature of participation and engagement in the lesson. Would you, would you describe that for me? Describe to me how you found your participation as learners in the class, compared to, maybe… other ways that you used to (not clear).
172.	EFGI/P3	You (not clear) half the class is… you know when you're in classroom and you are give a certain task and some of them will do it and some of them wont, but then you're in this one and everybody participated and everybody did what they were supposed to do, which is quite great.
173.	Steve	What other experiences did you guys find? When you were working with cell phones, how was it different from other lessons? Not only mathematics, maybe other subjects?
174.	EFGI/P1	There was much noise.
175.	Steve	Hey?
176.	EFGI/P1	There was much noise.
177.	Steve	Uhm, describe that noise for me?
178.	EFGI/P2	There was lots of shouting.
179.	EFGI/P3	Shouting?
180.	EFGI/P2	Yes.
181.	EFGI/P3	Really?
182.	EFGI/P2	But when there is no phones, it's fine
183.		Cell phone rings
184.	EFGI/P5	And, everyone..... everyone participated because they wanted to show the whole class their…their shape or whatever, yah, their result, so, everyone participated because they wanted to be the first to be done and show to the class. That was different because, the class exercise without

		cell phones, some wouldn't care.
185.	Steve	Okay. Who else has got a different experience? If you compare, I mean in usual lessons, every day lesson that you go to and the one that you had with the cell phone?
186.	EFGI/P3	Sometimes you get bored in a usual class, and you're like like, today is a bad teaching, I just wanna get out or I'll just sleep or read a book, because I don't wanna participate because, during this I didn't get bored
187.	Steve	Welcome back. Yah, others have said that experience, what would be your story in terms of participation and engagement. How busy were you in the class, what was the participation for everybody?
188.	EFGI/P1	We were more interested because it's the first time we were doing that on a phone.
189.	Steve	Guys, be honest with me, do you think there's someone who usually do not participate and you saw that person participating now or, maybe you know somebody who liked to participate so much but didn't participate in this lesson, he was a bit withdrawn…and kind of not willing to do anything. I want you to give a (not clear).
190.	EFGI/P3	Yah, I noticed somebody in class who was like; okay that's a bit (not clear), I'm just going with them. I'm not going to do anything and just pretend that I'm doing something, and that person (not clear) participated in this one.
191.	Steve	Okay, who else has seen something very critical that was very, very different?
192.	EFGI/P5	Well, I don't really like shapes and working with them…but then…and at first I…me and my partner were like failing. Because we were not doing good and when I wanted to stop the thing, she kept me going. (Not clear) cause if I did not have a partner, I doubt I would have participated. I would have but then I wouldn't have put my full heart into it.
193.	Steve	Okay,…
194.	EFGI/P3	I also don't like shapes.
195.	Steve	Yah, but what kept you going?
196.	EFGI/P3	Well it was interesting and usually when, during the year, we get to where we start doing shapes. I usually keep quiet in class and I don't say anything 'cause I don't know anything and I just grasp things here and there. And i… I really didn't like shapes before but this…it helped me a bit. Especially the triangles which I was really bad in but I think I have improved.
197.	Steve	Okay, lets the…something more or less towards the end. What else would you like to say about cell phones in the classroom?
198.	EFGI/P4	They're nice!
199.	Steve	I mean, you should…you should motivate your answer.
200.	EFGI/P3	Well, I understood things a lot faster than I usually do and their…you know kids nowadays we are all about cell phones, computers, and I think to bring something like that to class will motivate the whole class, not just…'cause some learners don't really like reading or listening to a

		teacher, and seeing things helps us a lot 'cause you don't always want to hear your teacher talk, yah, she doesn't like to hear her teacher talk, so, having a cell phone in class, it actually gives you a chance to think and you can read and you can replay the thing. So, sometimes the teacher says something and you're like, I didn't get that and I won't ask her and with the cell phones you can just, okay I'll play that again and see if I get it and then you do that until you get it.
201.	Steve	Somebody else? What else can you say about cell phones in the classroom?
202.	EFGI/P5	It was more fun because they were videos on shapes and colors. And sometimes the teachers were really boring like, you could hear her talking but then, she makes you wanna sleep. So with the videos, I think it was more fun. And the cutting, and the colouring in so, we really enjoying it because (not clear) writing.
203.	Steve	Yah. I mean, you have to say something, you know? What about you? What experience did you get about the cell phones in the classroom?
204.	EFGI/P6	I don't know what, uhm… its boring when the teacher is standing in front of you, I just get bored. I don't know, it's just the way they teach.
205.	Steve	But you think the cell phones are giving you something different?
206.	EFGI/P6	Yah.
207.	Steve	How about, maybe you use them for a whole year, you think at one point they're gonna be boring as well?
208.	Group	No!
209.	Steve	Why?
210.	EFGI/P4	Kids don't get bored by cell phones. I don't think that's possible in this age.
211.	EFGI/P5	And the teacher was talking less…
212.	EFGI/P4	Yah.
213.	EFGI/P5	So it was much better. Not that we don't like her talking because, yah, she gives clarity to some things, but then she was talking less, so it's much better.
214.	Steve	So you're saying, a cell phone and a teacher talking is much better?
215.	EFGI/P4 and EFGI/P5	Yah.
216.	Steve	Than the teacher talking without cell phones?
217.	Group	Yes.
218.	Steve	Okay…hmm? What do you think? About cell phone in the classroom? Just anything?
219.	EFGI/P4	(Not clear)
220.	EFGI/P2	They help us to understand.
221.	Steve	Hey?
222.	EFGI/P3	They help us to understand more quickly.
223.	Steve	Okay, I want to give each one of you now a chance 'cause, that will be my last part to…to sum up the whole experience of using cell phones,

		learning the Pythagoras Theorem, in this interview. So, I want to give each one of you three seconds to say something before we close the interview.
224.	EFGI/P5	Allowing cell phones in the class, it will be a huge step and I think it will take some times to get used to but then, it's much better. But I don't think I would be able to look at them the whole year, and the following year and the other year. I just think it's a bit too much.
225.	Steve	Okay. Okay? What would you like to say?
226.	EFGI/P6	I would like to say that uhm, let's use the cell phones some days…(not clear).
227.	Steve	Let's use the cell phones some days?
228.	EFGI/P6	Yah,…
229.	Steve	Okay.
230.	EFGI/P6	(Not clear)
231.	Steve	Okay. Who wants to go?
232.	EFGI/P4	I would say that to use a cell phone, automatically helps…helps to (not clear).
233.	EFGI/P2	Yah, I think we should use it because it helps me understand more quickly than the teacher telling me what to do.
234.	EFGI/P1	I think we should use the cell phones more often because it encourages people to do their work.
235.	Steve	You're the last one.
236.	EFGI/P4	Uhm, I kind of agree with (not clear) because, as…I don't think it would be good to use them the long whole year, 'cause it would get…not will but then, I don't think we should stop having the black board or the white board because they too help us to a certain extend 'cause, while using the cell phones, we did have to go to the board every once in a while. So, using them sometimes will be great but then not all the time. That's what I think.
237.	Steve	So, why do you think, not all the time?
238.	EFGI/P4	I'd end up getting bored. And I'd miss the teacher talking. And, sometimes it is nice hearing a teacher talk. Sometimes.
239.	Steve	Okay, thank you very much, guys. Uhm, that's the end of our interview. Thank you very much for your courage to volunteer and I also want you to pass my appreciation to the rest of the group for taking part in this study.

Appendix D: Deep HS Students' focus group discussion transcript

Transcript: Learners' focus group discussion **School:** Deep HS

Line No.	Speaker (s)	Conversation
After the greetings , setting a rapport with the participants, and assuring confidentiality, the discussion started		
240.	Steve	Thank you very much gentlemen. Let's start with our interview. Among this group I have here, who owns a cell phone? Who owns a cell phone, who has a cell phone?
241.		*Three out of six learners raise their hands.*
242.	Steve	Okay, but who doesn't have a cell phone but uses one. Maybe you don't have a cell phone for yourself, your own machine, but you do use a cell phone anyway?
243.		*Three learners raise their hands.*
244.	Steve	Okay, so tell me guys, what exactly do you do with a cell phone?
245.	DFGI/P1	Make calls.
246.	Steve	Overall, okay.
247.	DFGI/P2	When I am looking for the information, I look on the internet.
248.	DFGI/P3	Music. And we use it to calculate.
249.	Steve	Don't worry about my notes.
250.	DFGI/P1	Facebook.
251.	DFGI/P5	Facebook.
252.	Steve	Okay.
253.	DFGI/P1	Play games.
254.	DFGI/P2	Listening to music.
255.	Steve	Shout…shout, whatever.
256.	DFGI/P2	Watching videos.
257.	DFGI/P3	Taking photo.
258.	DFGI/P6	Okay, and messages.
259.	Steve	What else do you do with a cell phone? There might be a lot more. Finished?
260.	Group	Yah.
261.	Steve	Let's move on; now, when we started with this whole program of using cell phones in the classroom, what did you find fascinating or different when you used a cell phone in the classroom. Comparing to other normal day, I mean, what did you find good for you when you used cell phones in the classrooms, or what did you find different?
262.	DFGI/P2	The different is that when I am using my cell phone at home, I just look at videos of music videos, or something like fun, but in here at school we have like…it's being learned as…it is something that we learn from like, this Pythagoras things.
263.	Steve	Yah?

264.	DFGI/P4	Here at school we are not allowed to get our phones in the class but when this came up we are allowed to get the phones and it is…it is not normal to us. We are not used to using phones in the classes but…there…this phone thing really helped us because, when it is shown in the phone, you can see what you want to do, you can see the whole thing…when it is shown on the phone.
265.	DFGI/P2	And it is more than, just like, someone told you what to do. Eh, it is very good to see it than like when you explain it.
266.	Steve	Some other guys? What are your views? I mean, what did you find different from the usual way that you have lessons and then with the lessons you have a cell phone with you?
267.	Steve	Yah, you want to say something! Do say something!
268.	DFGI/P6	See, between my phone it has no Pythagoras thing but it is your phone that has Pythagoras.
269.	Steve	Is that it? Okay, listen to the next one: In what way do you think the VITALmaths video clips…the video clips that you were watching on the cell phone, in what way did you find them facilitating your learning? How did you find them helpful to learn? Yah, that's the question.
270.	DFGI/P2	Uhm, like I said, ehm, when you are watching something, it's more than you being told, because when someone is telling you something, you don't…you don't understand it clearly but when you are seeing it, like in a visual, then it's much helpful than…
271.	Steve	Who else think in another way that it was helpful?...
272.	DFGI/P1	Uhm, the teacher didn't have to like, write everything, write every instruction on the board. We just had to watch it in the video. It was also saving us time, so that we can finish everything in time.
273.	Steve	Yes, you wanted to say something?
274.	DFGI/P3	No.
275.	Steve	Okay, eh, Captain?
276.	DFGI/P4	You see the teachers don't always repeat the thing. When you're watching…watching it…if you…you can repeat it, repeat it and see what actually was going on.
277.	Steve	What else was helpful in the video clips? What did you find facilitating? Making things look a lot easier?
278.	DFGI/P4	It was interesting. Sometimes you get bored when the teacher is…is teaching us on the board so, while we are using the phones, the phones were interesting to us. But some us…some of us don't have phones, so.
279.	Steve	You want to add to that? When you say eh, "we get bored with the teachers teaching", what is it you are referring to?
280.	DFGI/P4	Sometimes.
281.	Steve	Yah, yah! Sometimes, I understand, sometimes…Now, how are you experiencing that..that…that boredom,? I mean, when the teacher is teaching, how do one get to the point where you feel like, "I'm bored"?
282.	DFGI/P2	Like, sometimes when it is very hot, maybe she is talking too much.

283.	DFGI/P6	And the afternoon classes…
284.	DFGI/P2	And sometimes you think like, when it's…she is teaching too much, your brain is not here, like you are thinking of something else.
285.	DFGI/P3	Maybe when it's just the phone, you just concentrate on the phone.
286.	DFGI/P4	Get interested.
287.	Steve	Oh, okay. Uhm, I've noticed that sometimes you work alone, sometimes you work with others, my question here is; when you work with others in the classroom, what did you find helpful or troublesome? I want you to compare a point where you worked alone and a point where you worked with others. So what…when you worked with others, what was helpful or what was not so good?
288.	DFGI/P2	Uhm, when we are working as partners, we share the knowledge. So, sometimes you make a mistake when you are alone and then, when you are with your partner he can give you that "no, this is wrong". And, the other thing about working with the partners is that, uhm, like, when you are working with your partner, you just like…your partner is just watching you working and you are working alone, sometimes.
289.	DFGI/P4	It's like they take advantage of you.
290.	Steve	Yes, what else did you find good working with others? Or bad, I mean, let's talk about everything.
291.	DFGI/P2	The other thing about working with partners, sometimes your partner is like, he's not interested in knowing this, You might or do work alone and then after that he doesn't know what happen, how did you get the answer or what did you do to do this. So, it's better to work alone
292.	Steve	What else?
293.	DFGI/P4	Others may not understand the thing so when we work together you may explain to them and they can explain to you what they…they know.
294.	DFGI/P2	And also, when we are working with videos and partners, neh, you…you'd be like, you'd explain this to him, but he'd be scared to ask. If he's working alone, he'd be scared to ask to the teacher, "what is happening here?" So it's better to ask your partner.
295.	Steve	Some guys are not saying anything. What do you have in mind when you have worked with your partner? Don't mind because he's here, but he not working with you all the time. Was it…was it him, all the time?
296.	DFGI/P4	No.
297.	Steve	But, okay, talk about… if you want talk about him, talk about the other guy who worked with you.
298.	DFGI/P5	We sharing ideas
299.	Steve	What…what else?
300.	DFGI/P5	He likes to work alone, this one. This guy. I try to go over to him but he would like, do it alone.
301.	Steve	So he's grabbing the papers from you?
302.	DFGI/P5	Yes.
303.	Steve	That's part of personality, you know. There are people just want to make sure they master the thingy. Let's move on; Pythagoras Theorem that

		you've been doing all the time, has been introduced to you already in earlier grades, if that's correct?
304.	Group	Yes.
305.	Steve	I don't know whether it's in eight, or Grade six…or Grade nine…? Somewhere there, somewhere there it was introduced to you. But I want you to compare what you have done in those grades and what we have done on the cell phones and tell me what the difference is. I want you to compare and contrast; give me what looks the same or what looks different between the other approach and the approach on the cell phones.
306.	DFGI/P2	I think it was the same but this one was more advanced.
307.	Steve	What do you mean when you say "advanced"?
308.	DFGI/P2	Like there are some changes. Like there in lower grades we just draw it…draw it in the paper and when couldn't cut and the stuffs.
309.	DFGI/P3	To make sure it's the perfect answer.
310.	Steve	Say again?
311.	DFGI/P3	To make sure it is correct.
312.	Steve	Okay, with the cutting?
313.	Group	Yes.
314.	Steve	Yes?
315.	DFGI/P4	When our teachers…when our teacher taught us these Pythagoras, he was…he wanted us to go to another school where there was…I don't know if it was a competition or something about this Pythagoras, so what I mean…
316.	DFGI/P2	He taught us in rush, because there was no time to like be in the everyday…like…he didn't explain this to us clearly, this Pythagoras to us clearly, so we just…like going through it in a rush.
317.	Steve	Yah-yah, what do you want to add?
318.	DFGI/P5	(Speaks IsiXhosa)
319.	Steve	Say anything, I mean, I don't know, it's your own views. What? You can't find the words?
320.	DFGI/P1	It is a bit clear now compared to uhm, the previous grades.
321.	Steve	Okay, let's move…let's move on and say; what was the nature of participation and engagement during the lessons with the cell phones?
322.	DFGI/P2	I beg your pardon?
323.	Steve	How…how did you your class as a whole…your participation, everybody's participation…how you self were engaged…I mean, how you were self busy, and then…compared to other lessons?
324.	DFGI/P1	Everyone was interested in using the cell phones.
325.	Steve	Say…say it, just repeat that for me again.
326.	DFGI/P1	Everyone was uhm, more interested in using the cell phones.
327.	Steve	I want to hear more stories. Yah?
328.	DFGI/P6	This was my first time to touch the cell phone.
329.	Steve	Yah? So, you like to touch it?
330.	DFGI/P6	Yah.

331.	DFGI/P4	A lot of…a lot of wnen were told by Ms. Deep (*not real name*) that we were going to use phones in the class. We were more interested because we thought we were going to get the phones to be ours.
332.	DFGI/P2	And she told us that if we work hard, then we…maybe we can get the phones.
333.	Steve	You want to have cell phones (not clear)? But, in the letter that I wrote to you and your parents I didn't say that I'm going to give you a phone. Did I? No, I didn't say that we were meant to be giving cell phones. But other than that, I want you to tell me how you sit in other classes and how you sit in this one with the cell phones; what did you see different in terms of participation and engagement and engagement is to when…how busy were you with these cell phones compared to other lessons. Were you less busy or were you more busy…or…? If you were of that nature…I want you to drive through that. Tell me experience.
334.	DFGI/P4	In our class or in all the subjects we're always busy so, we were busy in other classes and in other classes we are also busy so there's no difference in our business.
335.	DFGI/P2	And I think people focused more when they are using cell phones because you know you have to look the video and make sure what is seeing here. So if one flash off you won't know what is going on
336.	DFGI/P4	But even in the book, we concentrate. We also concentrate in the book.
337.	Steve	So do you think the book, the textbook and the cell phones are the same?
338.	Group	No.
339.	Steve	What is the difference?
340.	DFGI/P2	Sometimes the books are boring. Sometimes they are like black and white colors…that color is boring. And then when you are watching the cell phone then there is different views, then it seems interesting.
341.	DFGI/P4	The book may have more knowledge than the phone because the phone is just a small thing and when something…it is more…and then us get interested because they can get to finish it easily, like quickly. And, but the book, maybe the teacher say we must read that particular chapter and uhmmm.... that chapter is too big
342.	Steve	What else? Yes? No no! Say what you have here, don't…don't close it inside. No more other views? I mean, I want you to describe: do you think that everybody, when we were using this cell phone, was participating or did you see somebody who was a little bit…not really into it?
343.	DFGI/P1	Everybody was participating.
344.	Steve	Is that the same all over the other subjects? Are they lesson else elsewhere some of them are a bit sleeping or …
345.	Group	Yes.
346.	DFGI/P2	That's a problem. You know sometimes like, when you are coming here, then some of them are like "eish, I would like to…it would be better to go home because I'm going to the boring teacher" something like that. That's why the learners (not clear).
347.	Steve	But when the cell phones are coming, then everyone want to come?

348.	Group	Yes.
349.	Steve	You think it's true?
350.	Group	Yes.
351.	Steve	Or is it because I am here? You must tell me, "ah sometimes we just want to finish the business that we signed for" something like that. But anyway, I've noted that…yes? Something else? No other point? Okay, I'm moving toward the end now; in general, I want your stories now, we are concluding and I'm gonna give everyone maybe three seconds to tell me, what else would you like to say about cell phones in a classroom? Everybody will get a chance now. So, your opinion, your experience, and give more a bit of examples of what you have experienced with these cell phones in your Mathematic class. You want to start?
352.	DFGI/P4	When you use a cell phone, you get more interested, so if cell phones were used in all the different classes, we would be more interested to learn more with the cell phones.
353.	Steve	What is really interesting, working with cell phones?
354.	DFGI/P4	Because, cell phones are…are…are not used at school, so when they are used at school, we get more interested. Because it is something that is not much done in school.
355.	Steve	Okay, everyone will get a chance. If you want to go two times, that's also fine. Would you like to be the last one? No, you would be the last one. I want you to cover the other guys.
356.	DFGI/P3	I think using the cell phones was a great thing because, when you weren't using the phone just write the notes on…on…on a book and it was really hard because it takes maybe more times than when using a phone because, when using a phone, just click and go to thing that you're going to do.
357.	Steve	Are you saying it was faster?
358.	DFGI/P3	Yes.
359.	Steve	Okay, compared to copying notes. What else do you want to add? Okay.
360.	DFGI/P1	It is more or less what he said 'cause like, when we were using the cell phones we were able to finish everything in time.
361.	Steve	Now, you can take your shot. Take your shot. Just keep it to the camera.
362.	DFGI/P5	I think the cell phones was a great thing, because you just look through the phone and you finish fast and quick…and…
363.	Steve	If you want to say in isiXhosa, say it.
364.	DFGI/P5	Siyabona. (Continues speaking isiXhosa)
365.	Steve	So you say it was fast?
366.	DFGI/P5	Yes.
367.	Steve	Okay.
368.	DFGI/P6	(Speaks isiXhosa)
369.	Steve	Okay, I'm not going to allow you to speak IsiXhosa now so, try English.
370.	DFGI/P2	Okay, eh, working with cell phones was great but, something that bothers me is that every time we're using the cell phones and we're using like, this Pythagoras (not clear), I was hoping that we are going to learn like,

		maybe Algebra on phones, something like that. And equation and other things.
371.	Steve	I know, I have…I have other videos. I've got about thirty eight of them but I chose Pythagoras Theorem because I didn't want to mix up things. I said, "okay let's see how far we get with Pythagoras Theorem and then listen to what the students have to say". If they think it's a good idea then maybe we'll try another video but, I couldn't jump like this, cause then you might say "no, when we did Pythagoras and didn't understand (not clear)". I want us to cover one topic and then I hear from you, then from there (not clear) I want to come again and try another one and so and so on. You see what I'm saying so, just give me your views now around Pythagoras Theorem and the cell phones.
372.	DFGI/P2	Ehm…eish… Pythagoras Theorem seems…
373.	Steve	You must just give way for the video…yah.
374.	DFGI/P2	…seems much interesting, you know? Like,…like some…eish I don't know what I'm saying.
375.	Steve	Just eh…speak…speak your mind.
376.	DFGI/P2	I'm speechless.
377.	Steve	So you're finished? Is there somebody else who want to add anything? That was actually the last portion of our interview. But if somebody else's got a (not clear) they want to tell me, I'd want to listen to that as well. Anything else, gentlemen?
378.	DFGI/P4	(IsiXhosa and English mixed) It makes it easier for us to actually get what we want like the if "d" is with a "c", it makes it easier to get "d"…
379.	Steve	Okay.
380.	DFGI/P4	For an example.
381.	Steve	Okay, I have captured that. Yah, anything else?
382.	DFGI/P1	I think that's it.
383.	Steve	Okay, okay thank you very much gentlemen. That's the end of our interview…

Appendix E: Department of Education permission letter

Province of the
EASTERN CAPE
DEPARTMENT OF EDUCATION

Office of the District Director, *Private Bag X1001* Grahamstown *6140*
Tel: 046-603 3318
Enquiries: Mr. MC Gobane
Fax: 046-622-3288
Cell: 083 622 6331

SCIENCES FET

To: **The Principal**
From: **Mr L J Goosen DCES: Sciences**
Subject: **Mathematics Intervention**
Date: **20 June 2011**

Attention to whom it may concern:

Mr. Gerhard Ndafenongo, a full time MEd Student of Rhodes University MTEP Program has been granted permission to conduct a research on how to utilize the cellular phone in studying mathematics. This research will be conducted on our Gr. 10 Learners who are currently studying mathematics.

This cellular program will enhance and improve understanding of specific mathematical concepts and therefor improve our learner final results.

We urge that the gentleman be given an opportunity to conduct this activity, during a class or afternoon session.

Yours faithfully.

.....
Mr BMH Stamper
CES: Curriculum

Appendix F: School principals' consent forms

CONSENT FORM

I Mr. Edge HS Principal in my capacity as Headmaster hereby give written consent to Gerhard Ndafenongo, in his capacity as an MEd student at Rhodes University, to conduct research at Edge High School as outlined in the above document. Both parties understand that this consent can be revoked, without explanation, at any time.

Mr. Edge HS Principal
Principal (full name)

Signature & Date 25/07/2011

GERHARD NDAFENONGO
Student's full name

25.07.2011
Signature & Date

FRF MATHEMATICS EDUCATION CHAIR
EDUCATION DEPARTMENT
RHODES UNIVERSITY
P.O. BOX 94
GRAHAMSTOWN 6140

As witness:
Full name

2011-07-25
Signature & Date

CONSENT FORM

I Mr. Deep HS Principal in my capacity as Headmaster hereby give written consent to Gerhard Ndafenongo, in his capacity as an MEd student at Rhodes University, to conduct research at Deep High School as outlined in the above document. Both parties understand that this consent can be revoked, without explanation, at any time.

Mr. Deep HS Principal
Principal (full name)

Signature & Date

GERHARD NDAFENONGO
Student's full name

Signature & Date

As witness:
Full name

29/06/2011
Signature & Date

Appendix G: Teachers' consent forms

TEACHER'S CONSENT FORM

Full name: Ms. Edge	School: Edge HS
E-mail:	Contact number:

I have read the information provided for the study "An investigation into how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips" as described herein. The study is to be conducted by Mr. Gerhard Ndafenongo, in his capacity as an MEd student at Rhodes University. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

With particular reference to the audio-visual recordings, I hereby give consent to the following:

		*	
Yes	No		For 2 to 3 additional researchers to view portions of the videos in order to assist with the analysis thereof
Yes	No		For single frames of the video footage to be included in the final written thesis.
Yes	No		For single frames of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be used in teaching seminars for the purposes of teacher development

** Please TICK the appropriate box*

Signed: _____ Witness: _____

Date: 2011-07-25 Date: 25.07.11

TEACHERS CONSENT FORM

Full name: Ms. Deep	School: Deep HS
E-mail: N/A.	Contact number:

I have read the information provided for the study "An investigation into how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips" as described herein. The study is to be conducted by Mr. Gerhard Ndafenongo, in his capacity as an MEd student at Rhodes University. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

With particular reference to the audio-visual recordings, I hereby give consent to the following:

		*	
Yes	No		For 2 to 3 additional researchers to view portions of the videos in order to assist with the analysis thereof
Yes	No		For single frames of the video footage to be included in the final written thesis.
Yes	No		For single frames of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be used in teaching seminars for the purposes of teacher development

** Please TICK the appropriate box*

Signed: _____ Witness: _____

Date: 20-06-2011 Date: 20-06-2011

Template A: Students' information letter and consent form

Rhodes University, Grahamstown, South Africa
Education Department

Mathematics Education Master in Education Research Project

INFORMATION TO RESEARCH PARTICIPANTS

Introduction
I am Gerhard Ndafenongo, a full time M-Ed student (St no: g09n6060) at Rhodes University majoring in mathematics education. My research focus is an investigation into how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips. The headmaster of your school has granted permission for me to conduct the proposed research in his school. This letter provides important information regarding the study, and formally requests your consent for you to take part in the study.

Description of involvement
The pilot project or study orientation commences at the beginning of Term 3 of 2011. The data collection process involves audio-visually recording 2 - 3 lessons while you and the teacher are engaged in integrating cell phones in teaching and learning. Each learner will be provided with a cell phone by the researcher to use during the lesson. These will be returned after each lesson. During the lesson you will be viewing short VITALmaths video clips (designed for mathematical exploration) while receiving support and guidance from the teacher. This phase of the data collection process will be conducted during normal academic hours at times convenient to the teacher or as scheduled in the school timetable.

In the final stage of the study I will also have focus group discussion with approximately six randomly selected learners who took part in the study and volunteered to take part in the discussion. This will take place at school, a venue that learners are familiar with. They will thus not have to leave the school premises to participate in the study.

Risks and benefits
There are no foreseeable risks involved in participating in the study. The study of the Pythagorean Theorem has become an integral component across both the GET & FET phases of the South African school Mathematics curriculum. Additionally, Pythagoras's Theorem is one of the great theorems in mathematics it is useful as well as surprising. Your participation in the study will not only further your own understanding of and appreciation for this important section of the syllabus, but will ultimately contribute to the distillation of contemporary pedagogical strategies which will be able to be used in the classroom context to further other pupils' understanding of Pythagoras's Theorem.

Participants' rights
Your participation in this study is strictly optional, and at your own personal discretion. Should you agree to take part in the study you retain the right to withdraw at any point without explanation. Anonymity and confidentiality are guaranteed at all times, both during the research process itself and in the final written thesis. Unless you request otherwise, pseudonyms will be used to protect your identity in the final thesis.

Video recordings
The audio-visual recordings are necessary for detailed characterizing and deconstruction of your interaction, exploration and collaboration during the lesson using cell phones. It may be necessary for two or three other researchers to view portions of the videos in order to provide input during this analysis process.

Consent
After you have read and understood this letter, and made any necessary clarifications about your involvement in the research process, please complete and sign the attached form. Please note that should you agree to take part in this study I am obliged to approach your parents and/or legal guardian for their permission before commencing with the research process.

Sincerely,

_____
Gerhard Ndafenongo
0715404672
g09n6060@campus.ru.ac.za

RESEARCH PARTICIPANT CONSENT FORM

Learners' full name:	School:
Date of birth:	
Parent/legal guardian name:	Grade:

I _____ hereby agree to take part in the research study to be conducted by Mr. Gerhard Ndafenongo, an MEd research student in the Education Department of Rhodes University, Grahamstown. I understand what will be required of me in the role of research participant. Furthermore, I am aware that I retain the right to withdraw from the research project at any point without explanation.

With particular reference to the audio-visual recordings, I hereby give consent to the following:

Yes	No	*	
Yes	No		For 2 to 3 additional researchers to view portions of the videos in order to assist with the analysis thereof.
Yes	No		For single frames of the video footage to be included in the final written thesis.
Yes	No		For single frames of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be used in teaching seminars for the purposes of teacher development.

* Please TICK the appropriate box

Signed: _____ Witness: _____

Date: _____ Date: _____

Template B: Parents'/Guardians' information letter and consent form

Rhodes University, Grahamstown, South Africa
Education Department

Mathematics Education Master in Education Research Project

INFORMATION TO PARENTS'/GUARDIANS' OF RESEARCH PARTICIPANTS

Introduction
I am Gerhard Ndafenongo, a full time M-Ed student (St no: g09n6060) at Rhodes University majoring in mathematics education. My research focus is an investigation into how cell phones can be used in the teaching of Mathematics using *VITALmaths* video clips. The headmaster of your child's school has granted permission for me to conduct the proposed research in his school. This letter provides important information regarding the study, and formally requests your consent for your child to take part in the study.

Description of involvement
The pilot project or study orientation commences at the beginning of Term 3 of 2011. The data collection process involves audio-visually recording 2 - 3 lessons while teachers and learners are engaged in integrating cell phones in teaching. Each learner will be provided with a cell phone by the researcher to use during the lesson. These will be returned after each lesson. During the lesson learners will be viewing short VITALmaths video clips (designed for mathematical exploration) while receiving support and guidance from the teacher. This phase of the data collection process will be conducted during normal academic hours at times convenient to the teacher or as scheduled in the school timetable.

In the final stage of the study I will also have focus group discussion with approximately six randomly selected learners who took part in the study. This will take place at school, a venue that learners are familiar with. They will thus not have to leave the school premises to participate in the study.

Risks and benefits
There are no foreseeable risks involved in participating in the study. The study of the Pythagorean Theorem has become an integral component across both the GET & FET phases of the South African school Mathematics curriculum. Additionally, Pythagoras's Theorem is one of the great theorems in mathematics it is useful as well as surprising. Your child's participation in the study will not only further his own understanding of and appreciation for this important section of the syllabus, but will ultimately contribute to the distillation of contemporary pedagogical strategies which will be able to be used in the classroom context to further other pupils' understanding of Pythagoras's Theorem.

Participants' rights
Your child's participation in this study is strictly optional, and at his and your own personal discretion. Should you agree for your child to take part in the study he/she retains the right to withdraw, without explanation, at any point. Anonymity and confidentiality are guaranteed at all times, both during the research process itself and in the final written thesis.

Video recordings
The audio-visual recordings are necessary for detailed deconstruction and characterizing of the lessons. It may be necessary for two to three other researchers to view portions of the videos in order to provide input during this analysis process.

Consent
After you have read and understood this letter, and made any necessary clarifications about your child's involvement in the research process, please complete and sign the attached form if you are willing for your child to take part in the project.

Sincerely,

_____
Gerhard Ndafenongo
0715404672
g09n6060@campus.ru.ac.za

PARENT/GUARDIAN CONSENT FORM

FULL NAME: _____

PHONE NUMBER: _____

I _____, in my capacity as parent/guardian, hereby give consent for _____ to take part in the research study to be conducted by Mr. Gerhard Ndafenongo, an MEd research student in the Education Department of Rhodes University, Grahamstown. I understand what will be required of my child in his/her role as research participant. Furthermore, I am aware that my child retains the right to withdraw from the research project at any point without explanation.

With particular reference to the audio-visual recordings, I hereby give consent to the following:

Yes	No	*	
Yes	No		For 2 to 3 additional researchers to view portions of the videos in order to assist with the analysis thereof.
Yes	No		For single frames of the video footage to be included in the final written thesis.
Yes	No		For single frames of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be included in conference presentations.
Yes	No		For short clips of the video footage to be used in teaching seminars for the purposes of teacher development.

* Please TICK the appropriate box

Signed: _____ Witness: _____

Date: _____ Date: _____