Paperless classroom experiences in Grade 7 mathematics in township schools

by

Kgabo Ezekiel Kganyago
27645755

Submitted in partial fulfilment of the requirements for the degree in
Magister Educationis General

Department of Science, Mathematics and Technology Education
Faculty of Education
University of Pretoria

Supervisor: Dr. R. Callaghan

Date of submission
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Declaration

"I declare that the dissertation, titled: **Paperless classroom experiences in Grade 7 mathematics in township schools**, which I hereby submit for the degree **Magister Educationis (General)** in Education at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution."

Surname, Initials: Kganyago K.E.

Student Number: 27645755

Signature _____ Date: __/ 09 /2018

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Abstract

The implementation of technology into the curriculum is becoming an inseparable part of good and quality teaching. The Gauteng Department of Education (GDE) has recently introduced paperless classrooms for teaching and learning in township schools with the aim to improve and ensure credible and quality education for all learners in Gauteng. Therefore, this study aimed to investigate paperless classroom experiences in teaching and learning of Grade 7 mathematics in township schools. The research question sought to answer how the experiences of teachers and learners in Grade 7 mathematics in township schools can inform further rollout of paperless classrooms.

The research design was based on the Technology Acceptance Model. The research was conducted in a descriptive paradigm, using the case study method. Data collection instruments that were utilised are lesson observations, semi-structured interviews and focus group discussions. The participants were mathematics teachers and learners in Grade 7. The samples were purposefully selected and consisted of one mathematics teacher and a group of learners in each school. In school A, there was one teacher and forty six learners and in school B one teacher and forty seven learners. The two schools are currently piloting the implementation of smart boards and tablets for teaching and learning.

Participants in both schools acknowledged that the positive experiences relating to the implementation of technology, were, amongst others, the provision of ICT infrastructure by the Department of Education; enhancement of quality teaching and learning; less paper; quick accessibility of resources; and free Wi-Fi . They also argued that while the paperless classroom initiative brought positive experiences, some issues remain unresolved, for example insufficient training and technical support, anti-social behaviour by learners and technophobia by older teachers. Based on the research, some of the suggestions for further rollout are improved training and technical support, as well as updating the Department of Education guidelines on the use of ICT in schools.

Keywords: Paperless classroom, smart boards, tablets, technology acceptance, mathematics

Language editor`s disclaimer

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0176
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Anna M de Wet

BA (Afrikaans, English, Classical Languages) (Cum Laude), University of Pretoria.
BA Hons ((Latin) (Cum Laude), University of Pretoria.
BA Hons (Psychology) University of Pretoria.

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Above all, I would like to thank God, the Almighty, for his grace and blessings.

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Abbreviations

AMESA: association of mathematics education South Africa

BYOD: Bring Your Own Device

CAPS: Curriculum and Assessment Policy Statement

CEO: Chief Executive Officer

CWTA: Canadian Wireless Telecommunications Association

DBE: Department of Basic Education

DoE: Department of Education

E-Education: electronic education

E-Learning: electronic learning

EN: Ekurhuleni North

E-School: electronic school

FET: Further Education and Training

GDE: Gauteng Department of Education

GET: General Education and Training

GoL: Gauteng Online

ICT: Information and Communication Technology

MEC: Member of Executive Council

NCS: National Curriculum Statement

NEPAD: New Partnership for Africa's Development

OBE: Outcome Based Education

RNCS: Revised National Curriculum Statement

SGB: School Governing Body

TAM: Technology Acceptance Model

TIMSS: Trends in International mathematics and Science Study

TRA: Theory of Reasoned Action

Key concepts

Connectivity: the ability of a computer to connect to the internet.

E-Learning: refers to the use of ICT to enhance and support teaching and learning processes. It is learning that is facilitated and supported through the use of technology.

Paperless classroom: an integration of technology in the classroom that eliminates all purposes of paper and ink.

Pilot School: a school chosen to test (try out) the use of technology in teaching and learning with a view to implementing it more widely.

Projector: a device that is used to project rays of light, especially an apparatus with a system of lenses for projecting slides on a screen.

Quintile: a statistical value of a data set that represents 20% of a given school population.

Server: a device on a network that stores, distributes and manages network resources.

Smart board: a digital, touch sensitive whiteboard that uses touch detection for user input.

Tablet: a mobile device with a touchscreen display.

Technology integration: when classroom teachers use technology to introduce, reinforce, extend, enrich, assess and remediate learners' mastery of curricular targets. Learners are able to use the technology devices that they are familiar with in order to create, explore and take control of their own learning.

Wi-Fi: a technology that uses radio waves to provide network connectivity

CHAPTER 1: INTRODUCTION

1.1. INTRODUCTION

Information and communication technology (ICT) is said to improve educational competences and is considered a significant means to address educational shortcomings in the developing world (Mlitwa & Koranteng, 2013). The introduction of ICT in education continues to create opportunities and pose challenges both worldwide and locally in South Africa (Meyer & Gent, 2016). It can enable and enhance the teaching and learning practice. The Department of Basic Education (DBE) requires that involvement in the technology environment be supported by effective e-learning that integrates learner-centred approach, be cooperative and develop higher level thinking skills (Department of Basic Education, 2012). Apart from curricular changes, workshops and short training courses introduce new technologies and activities or promote materials. For example, the practice of technology devices such as smart boards and tablets have been integrated as a tool for mathematics teaching in the classroom (Blackwell, 2013).

ICT is believed to be powerful in imparting information in several ways and this is done through text, pictures and videos (Kalas, Bannayan, Conery, Laval, Laurillard, Lim & Turcsanyi-Szabo, 2012). The main purpose of ICT integration into the curriculum is to create a conducive and flexible environment for teaching and learning. The attitude of teachers towards ICT integration into the curriculum can also play a significant role (Albirini, 2006). Therefore, it is imperative that teachers are made aware of the value of technology to enhance pedagogy. In addition, teachers who are positive towards ICT can successfully implement it in the classroom. It needs to be used under the right environment with suitable resources, training methods and support so that it can meet the learning needs of the learners.

1.2. BACKGROUND

The study aims to investigate the experiences of teachers and learners in Grade 7 mathematics in township schools. This could inform further rollout of paperless classrooms. The DBE through

its policy on e-learning (Department of Education, 2004b) and the Guidelines for Teacher Training and Professional Development (Department of Education, 2007) has established guiding principles which can be used to distribute and use the technology resources in schools. It is understood that the findings from the Pan African Research Agenda (2008 – 2009) revealed that the policy is not properly effected by countries which are trying to set themselves free from the socio-economic digital divide (Bingimlas, 2009). Schools which were less privileged continue to struggle to maintain the same standard as the well-resourced schools. The lack of resources cannot be seen as the main factor, it depends on how teachers use the available educational resources in their teaching practice (Bingimlas, 2009).

Paperless classroom is a concept that refers to the implementation of technology in the classroom that reduces the amount of paperwork and ink (Carley, 2013). The researcher is a teacher in one of the pilot schools in the Gauteng province in South Africa that are integrating smart boards and tablets into teaching of mathematics. Smart boards are connected in mathematics classrooms at the schools where the study was conducted. Several schools in Gauteng have since aligned their curricula with the technology environment and many teachers are now using technology to prepare their lesson plans.

1.3. RESEARCH FOCUS

This research focuses on investigating the implementation of paperless classroom in mathematics lessons in two primary schools. It will describe the experiences and problems of the participants in using smart boards and tablets in the classroom.

1.3.1. Problem statement

ICT is said to improve the educational competencies and is considered a significant means to address educational shortcomings in the developing countries (Mlitwa & Koranteng, 2013). However, there are challenges that hinder effective integration of ICT in the classroom such as infrastructure, resistance, electricity and teachers' ability to use technology (Mingaine, 2013).

Three issues that will be discussed here are the implementation challenges; teacher training; technical aspects and the researcher's experiences.

1.3.1.1. Implementation challenges

Technical support - refers to a specialised skill that is able to provide maintenance and assist the teachers and learners in implementing technology (Moses, Bakar, Mahmud & Wong, 2012). It does motivate teachers to use technology and integrate ICT into the teaching and learning practice (Hennessy et al., 2010). Therefore, it is important to provide support and services as part of the technology application.

Anti-social behaviour - describes activities that cause anxiety, distress or damage to another person. There are several learners who have witnessed or have been the victims of anti-social behaviour. The use of technology devices has produced the quick rise of a host of new form of anti-social behaviour with terminologies such as cyberbullying (Benhayon, 2013).
Lack of skills and knowledge - In some countries, teachers with low basic computer skills and knowledge have been recognised as the main challenge in integration of ICT in schools (Dzidonu, 2010).
Available information - There is a risk that learners may be confused by a variety of available information from which to choose (Mikre, 2011). In addition, the dominance of unwanted websites poses a risk to learning as learners pay their attention to unsolicited contents, such as pornographic material (Devadason & RECSAM, 2010) The dominance of unwanted websites is a serious challenge that distract learning and teaching because the teacher focuses more on trying to keep discipline (Mikre, 2011).

1.3.1.2. Teacher training

Technophobia is perceived as fear or dislike of advanced technology devices. It is a sense of an irrational fear (Benhayon, 2013). The availability of ICT in the classroom is seen as technology resources which will help teachers and learners do well in a modern learning environment. These technologies are motivating factors and allow teachers and learners

access to more information. They also enhance learners' understanding and participation by allowing them to learn in different ways (Sung, Chang, & Liu, 2016). It is important, however that teachers are supported to overcome their fears, understand the positive aspects and are trained to use technology.

1.3.1.3. Technical aspects

Infrastructure - The first step towards ICT deployment in education is to provide schools with the necessary ICT infrastructure, namely: desktop computer, laptop, server, printer, tablets, smart boards, projector and interactive whiteboard (Department of Basic Education, 2012). ICT infrastructure includes all available technology devices, software and internet connectivity in the school. The shortage of technology devices act as one of the factors that prevent the implementation of ICT into learning processes. Teachers need to have the necessary technology resources in order to employ technology in the classroom.

Internet connectivity – The school network needs to be reliable to encourage user confidence and to support learning and teaching. Broadband is a general term used to describe high-speed connectivity with the internet and between schools and other institutions and networks (Saunders, McClure, & Mandel, 2012). It can change the manner in which ICT is used in a school. It connects educators and learners to various resources of the internet and facilitates communication and collaboration (Sheninger & Murray, 2017).

1.3.1.4. The researcher's experiences

The researcher is currently teaching at one of the pilot schools that have introduced smart boards and tablets for teaching and learning in Grade 7. As ICT coordinator, the researcher has experienced some problems which delay full implementation of ICT in the classroom. These include the problems mentioned, namely training of teachers on the use of the smart board, technophobia, technical issues, connectivity and anti-social behaviour by learners on the tablets, i.e. cyber bullying and internet pornography.

The high cost for maintenance of ICT infrastructure, technical support and software licenses continue to hamper adoption of technology in schools. In spite of the status of technology in schools and the guiding principles developed by the DBE, research has revealed that there are some schools that are not effectively integrating technology to support teaching and learning in the classroom (Manduku, Kosgey, & Sang, 2012). It was discovered that regardless of the benefits of technology, the school management had not fully applied the policy developed by the Department of Education (DoE) (Manduku et al., 2012). Mingaine (2013) asserted that some schools developed their own ICT policy but it is not being implemented.

Based on the above-mentioned problems, it shows that schools are unable to implement ICT into a clear framework at a school level. These problems suggest that in order for schools to successfully integrate ICT, there must be adequate planning and consideration of what can realistically be sustained with regard to infrastructure and human resources. Against this background, this study seeks to answer the following questions.

1.3.2. Primary research question

The current South African government's effort to integrate technology into the South African curriculum, especially in Gauteng, is supported by research into how the programme is implemented and the effects that it may have on the teaching and learning situation. Hence, the research seeks to answer the following primary question:

RQ. How can the experiences of teachers and learners in Grade 7 mathematics in township schools inform further rollout of paperless classrooms?

1.3.3. Secondary research questions

In order to provide in-depth understanding of paperless classroom, these secondary questions were designed;

SQ 1. How do teachers use smart boards and tablets in Grade 7 mathematics classrooms?

SQ 2. What are the problems confronted by teachers and learners when using the technology in teaching and learning of mathematics?

SQ 3. What are the positive experiences acknowledged by both teachers and learners when using technology in teaching and learning?

1.3.4. Rationale

Mathematics has been perceived by many learners as a challenging subject. This notion is supported by the Annual National Assessment's results for mathematics from the year 2012 to 2014 (Department of Basic Education, 2014a). Learners need to be more familiar with the basic concepts of mathematics to enable them to make informed decisions in life and enhance their critical and problem solving skills. Many routine tasks have now become computerised, work places require higher level skills that are developed through mathematics education. Furthermore, situations at school level have transformed in recent years as a result of the introduction of technology. A new teaching approach that combines the use of smart boards and tablets has been introduced.

According to the Department of Basic Education (DBE), only 26% of South African teachers have basic computer skills, with only 7% at intermediate competency level (Alfreds, 2016). These are poor statistics, particularly for a country that has been vocal about ensuring that technology education becomes a national priority to support the rollout of paperless classrooms (Alfreds, 2016). In order to drive the government's objective of classroom of the future as they are commonly called, in 2014 the Gauteng Department of Education (GDE) announced a R17 billion five-year investment in paperless classrooms, with pilot phases well underway (Gauteng Department of Education, 2015). This indicates that South Africa has woken up to the need to address the digital divide in schools. These developments present a valid reason for this study. The above government program planned to see the launch of e-Learning in all township and rural schools by the end of 2018. Similar initiatives are emerging across several provinces around the country.

However, research on the state of technology integration in South African schools remains limited. Therefore, this study will contribute towards the existing gaps by elaborating on the

experiences of teachers and learners in Grade 7 mathematics in township schools to inform further rollout of paperless classrooms.

1.3.5. The aim of the research

The aim of the research is to describe the experiences and problems of the implementation of technology in the classroom to inform future implementation of similar technologies in education. The researcher hopes to determine the extent to which smart boards and tablets are being used in mathematics lessons. Data will be gathered from both teachers and learners in order to discover the experiences and challenges.

1.4. LITERATURE SUMMARY

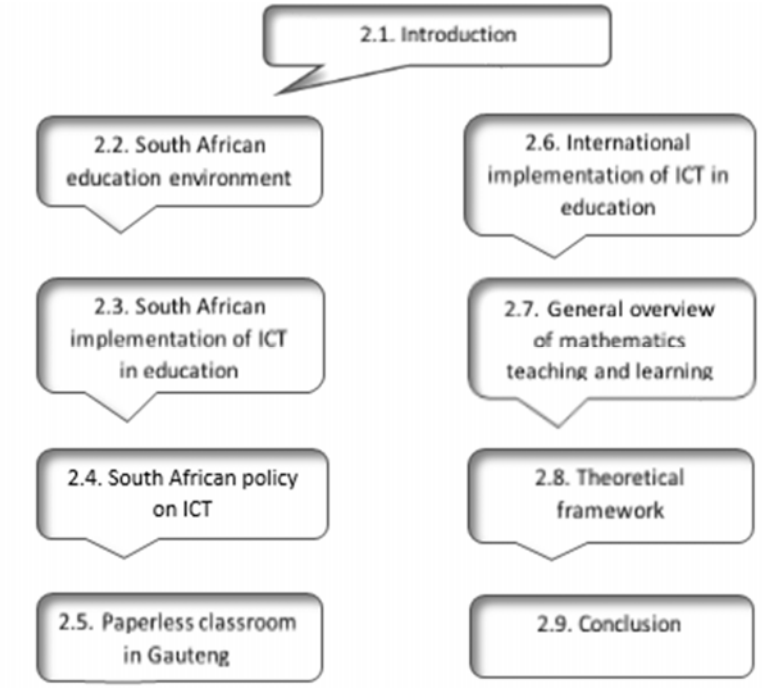

Figure 1. 1: Literature review layout

The literature summary provides an indication of the study in Chapter 2 as outlined in Figure 1.1. The main focus in Section 2.2 is to clearly provide a summary of the South African

education environment. It provides an overview of how the South African school system is organised and governed. It describes the different categories from quintile one to five and how they are funded. Section 2.3 is about South African implementation of ICT in education. It clarifies the implementation of ICT in schools (Howie & Blignaut, 2009). The DoE piloted a baseline survey in 2007 to determine the availability of ICT in schools (Farrell & Isaacs, 2007). Section 2.4 describes South African policy on education. It further explains its purpose in the implementation of ICT in schools. Section 2.5 presents paperless classroom experiences by teachers and learners in mathematics which involves the use of technology such as smart boards, tablets and laptops with internet to support the learning process (Gauteng Department of Education, 2015). It describes the purpose of paperless classroom and how it benefits the teachers and learners. Section 2.6: International implementation of ICT in education. The review revealed that considerable development has been made in an effort to integrate ICT in East African schools (Kimenyi & Kibe, 2014) which is discussed in Section 2.6.1. The use of ICT in Singapore is outlined in Section 2.6.2. It is alleged that the government encourages the integration of technology to enhance teaching and learning (Yoong, Yee, Kaur, Yee, & Fong, 2009). General overview of mathematics teaching and learning is discussed in Section 2.7. This section includes the general perspectives and beliefs about mathematics teaching and learning, using technology. This research will use Technology Acceptance Model (TAM) as a conceptual framework to explain the antecedents of behavioural intentions which in turn determine actual use as discussed in Section 2.8.

1.5. RESEARCH METHODOLOGY

Research methodology is a strategic framework of the research process to be employed in this study. The research onion, proposed by Saunders, Lewis and Thornhill (2007) creates a visual and clear picture of the complete research process. The figure below shows various stages of the methodological steps that are included in planning a research project.

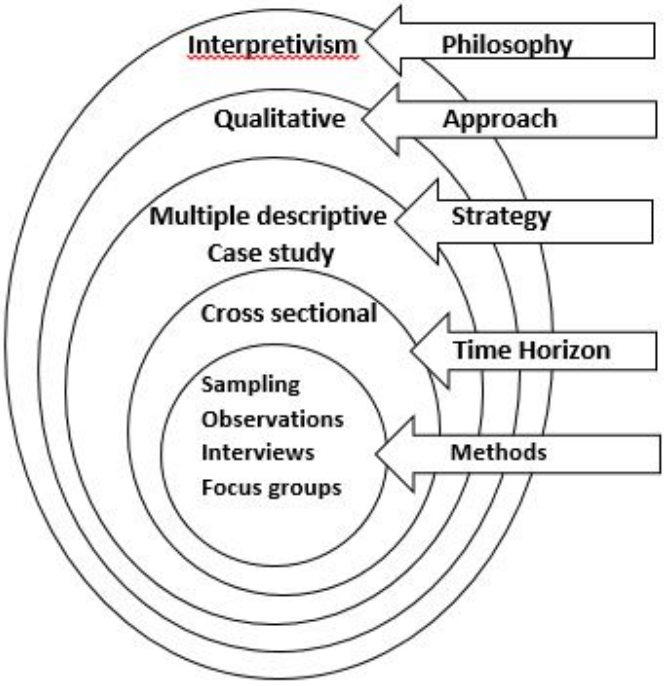

Figure 1. 2: Research onion

(Source: Saunders, Lewis & Thornhill, 2007)

The research onion was developed by Saunders, Lewis and Thornhill (2007) to describe the research development process when formulating an effective methodology. Figure 1.2 illustrates different stages to be followed by the researcher during the research process. Each element in a different layer is discussed in Chapter 3 to justify why they were chosen while conducting research.

The research approach is qualitative as explained in Chapter 3 paragraph 3.4.2. Multiple case study was chosen as a research strategy to investigate the experiences of teachers and learners in Grade 7 mathematics paperless classrooms in township schools. The time horizon was cross-sectional as all data was collected in a specific time frame.

1.6. DATA COLLECTION

The data collection instruments were used by the researcher to conduct classroom lesson observations supported by digital voice-recordings, semi-structured interviews and focus groups with the participants focused on understanding their perceptions of their daily experiences in the classroom (McMillan & Schumacher, 2010).

1.7. POPULATION AND SAMPLING

Population refers to people or cases from which a sample is selected and to which the findings can be generalised (McMillan & Schumacher, 2010). The population of this study is all teachers and learners in the two primary schools where technology is implemented.

The sample was selected with a specific aim, thus respondents are expected to be familiar and experienced about the implementation of smart board and tablets in teaching and learning. The samples were purposefully selected and consisted of one mathematics teacher and a group of learners in each school. In school A, the total number of learners in the Grade 7 class were forty-six learners and in school B forty-seven learners. The two schools are currently piloting the implementation of smart boards and tablets for teaching and learning.

1.8. LIMITATIONS

There are only two primary schools in the township in Gauteng that are currently integrating smart boards and tablets for teaching and learning. Therefore, the results of this research will apply only to these two participating schools. Many schools in the township have not yet started implementing ICT for teaching and learning.

Observation sessions – when teachers in both schools were demonstrating how they used tablets during teaching session, some learners could not use their devices due to other circumstantial factors. As a result, not all learners were able to use their tablets. However, there was still sufficient data collected for analysis. The fact that only two primary schools were

selected for this study will limit the generalisability of the findings across the schools in the entire province.

Interview sessions were planned and added to the depth of knowledge and provided insight. Due to time constraints, only one interview session with each teacher from each school and one focus group from each school were conducted. Teacher-participants were either attending cluster meetings or were busy with extra-mural activities.

1.9. ETHICAL CONSIDERATIONS

Research ethics are focused on what is ethically right and wrong when engaged with participants (McMillan & Schumacher, 2010). They are developed to provide guidelines for practice so that participants are protected from harm. Amongst these principles are informed consent; privacy and confidentiality. The ethical considerations are discussed in Chapter 3. The research proposal was presented and successfully defended to the university's ethics committee whereby ethical clearance was granted. The GDE, schools, teachers, parents and learners also granted permission to conduct research by signing consent letters.

The respondents were fully informed about the aim of the research. They were advised that they were giving consent voluntarily and could withdraw from the study anytime they felt so.
The researcher ensured participants that anonymity, privacy and confidentiality would be maintained throughout the study. They were further given assurance that their answers will not be revealed to other people. Their names and identity will not be revealed for any other purpose. Fictitious names would be used to replace their real names to protect their identity. Consent letters that were issued to the participants are attached in Appendices C – F.

1.10. OVERVIEW OF CHAPTERS

Dissertation structure

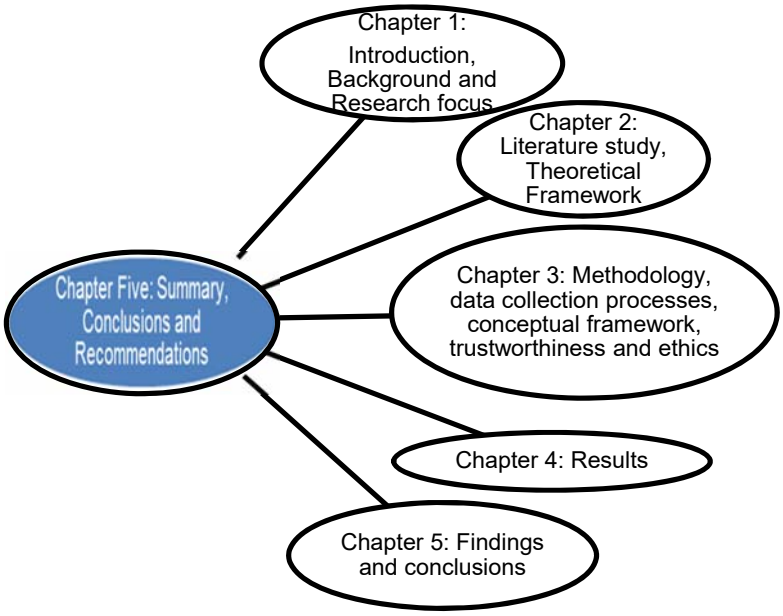

Figure 1. 3: Diagram of dissertation layout

Figure 1.3 provides a diagram of the dissertation layout and details of the structure are provided below:

- **Chapter One** provides a summary of the research and addresses the introduction, background, research focus, methodology, data collection, population and sampling, limitations and ethical considerations.
- **Chapter Two** links the relevant literature study and gives a general overview of mathematics teaching and learning, South African education environment, South African implementation of ICT in education, South African policy on ICT, Paperless classroom, International implementation of ICT in education and theoretical framework.
- **Chapter Three** describes the methodology, time horizon, participants, data collection process, conceptual framework, data analysis, categorising, trustworthiness, limitations and ethical considerations.

- **Chapter Four** discusses the data analysis process, research problem and question, discussion of results, findings and conclusion.
- **Chapter Five** provides for summary of the research questions, presents findings, proposes practical implications and identifies limitations and a suggestion of further research and conclusions.

1.11. CONCLUSION

This chapter introduced the core aspect of the research on the paperless classroom experiences in Grade 7 mathematics lessons in township schools. The research entailed a brief discussion of the background, research focus, research questions and literature review guiding this research. The chapter gave the summary of methodology and method to be used in data collection and analysis. It also presented the data analysis and dissemination of findings.

CHAPTER 2: LITERATURE STUDY AND THEORETICAL FRAMEWORK

This chapter presents a discussion on the aspects that underpins the paperless classroom experience in mathematics teaching in the South African context. It commences with a general overview of mathematics teaching and learning, followed by information about the South African education environment, and discussions on ICT implementations in education. Lastly the Technology Acceptance Model is presented as a theoretical framework for this study. The layout is illustrated in Figure 2.1

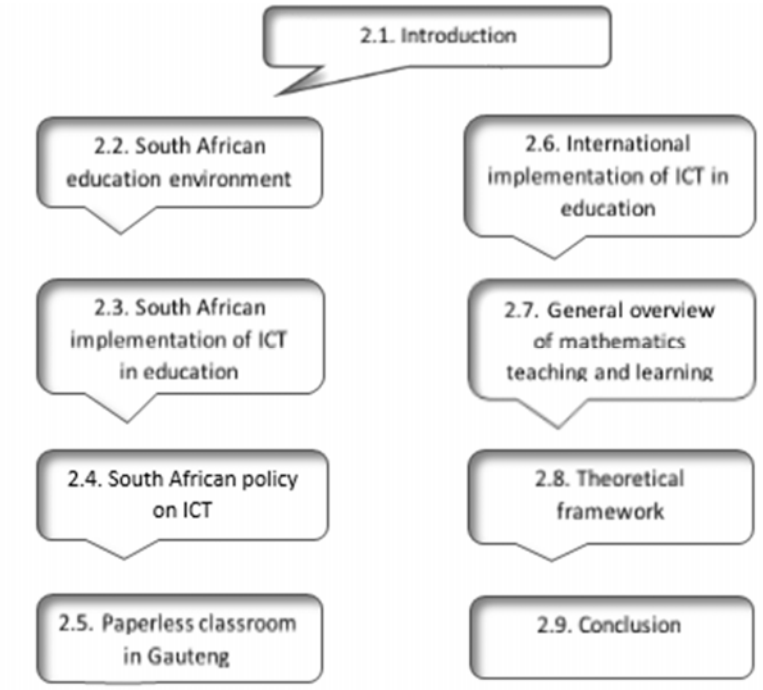

Figure 2. 1: Literature study layout

2.1. INTRODUCTION

Technology is becoming more prominent in today's classrooms (Hobgood & Ormsby, 2011). Teachers and learners are using smart boards and tablets for teaching and learning purposes. These technology devices are very helpful and useful for both teachers and learners in teaching and learning new materials and lessons. There are a wide variety of choices available online which makes it easier for learners and teachers to use (Hobgood & Ormsby, 2011). Teachers are able to modify lesson plans and activities according to their learners' needs. They can also share materials and lessons with other colleagues from other schools to collaborate in developing them.

ICT and its ongoing developments have recently enhanced numerous competencies (Kamba, 2011). The significance of e-learning for teaching purposes is that it allows learning to take place at any given time (Jethro, Grace & Thomas, 2012). There are software which help to simplify difficult concepts, making learning fun and easy (Mlitwa & Koranteng, 2013). Technology helps learners to carry out practical activities, for example, experiments and PowerPoint presentations. With all the skills of ICT and its continuous innovations for the teaching and learning process, the government expected all learners in South Africa to have access to ICT and to be competent, however this has not happened (Mlitwa & Koranteng, 2013). Full access to the benefits of technology for teaching and learning is limited to the advantaged few in more urban areas whilst learners in disadvantaged areas are deprived of the chances of gaining good quality education (Mlitwa & Koranteng, 2013).

ICT could enable and enhance the teaching and learning process. The DBE required that participation in the information society means, "every learner in primary and secondary schools will be ICT skilled (Wilson-Strydom, Thomson, & Hodgkinson-Williams, 2005). Full involvement in the information society is enabled by effective e-education that integrates learner-centred, research-based, cooperative learning to develop high level thinking skills (Ramorola, 2010). Apart from official curricular changes, workshops and short training courses introduce new techniques and activities or promote materials. The practice of technology devices, for example

smart boards and tablets, have been integrated as a tool for mathematics teaching in the classroom (Blackwell, 2013).

2.2. THE EDUCATION ENVIRONMENT IN SOUTH AFRICA

The school system includes public and private schools and both are managed by the DBE (Department of Education, 2010). The DBE distributes its roles through nine provincial education departments. These provinces are required to implement national policies and address issues that affect them locally. The South African school system is structured into two broad bands namely; the General Education and Training (GET) band and Further Education and Training (FET) band (Department of Education, 2010).

The GET consists of three phases which are Foundation Phase (FP) – grades 1 – 3, Intermediate Phase (IP) – grades 4 – 6 and Senior – grades 7 – 9. Primary school starts from Grade R to 7. The DBE is still in the process of merging Grade R into mainstream education. Secondary school starts from Grade 8 to 12 (Department of Education, 2010).

The public schools are arranged into five groups called quintiles (Department of Basic Education, 2014a). This is done for allocating financial resources accordingly. Quintile one is regarded as the least advantaged school while five is a well-resourced school. The national department is responsible for determining these rankings informed by the socio-economic factors of the school community. The government declared all township and rural schools as no fee-paying, while former model C schools are fee-paying schools. Poor schools are ranked at a lower quintile, whilst better-resourced schools are ranked higher. Below is the National table of targets for the school allocation from 2015 – 2017 (Department of Basic Education, 2015).

Table 2. 1: School allocation targets

(Source: Department of Basic Education, 2015)

Category	2015	2016	2017
National Quintile One	R1 116	R1 177	R1 242
National Quintile Two	R1 116	R1 177	R1 242
National Quintile Three	R1 116	R1 177	R1 242
National Quintile Four	R559	R590	R627
National Quintile Five	R193	R204	R215

The above table illustrates the allocation of funds per learner per year for each school ranking as approved by the National Department of Education (Department of Basic Education, 2014). The allocation of funds to schools is used to pay municipal services, stationery and teaching aids and maintenance and services (Department of Basic Education, 2014).

2.3. SOUTH AFRICAN IMPLEMENTATION OF ICT IN EDUCATION

The DBE has acknowledged that the South African provinces are at different levels with regard to ICT integration (Department of Education, 2004b). Some schools are equipped with computer centres, laptops, printers, internet connectivity and are efficiently using ICT in the school whereas some do not have enough resources and cannot even afford to purchase a computer. The department also raised the issue of infrastructure contributing to the digital divide between Africa and the developed countries (Department of Education, 2004a). There are also non-technical factors that affect the adoption of ICT in schools such as low levels of ICT literacy and technophobia amongst the teachers (Department of Education, 2010).

In order to overcome these factors, the White Paper on e-Education and the teacher laptop initiatives (initiated in 2009) are examples of initiatives to support teachers and schools towards using ICT (Department of Education, 2010). Technological change can become a major vehicle in education realising far beyond the more immediate goals of improving learner performance (Butler-Kisber, 2013). The DBE, for example, partnered with local and international ICT companies to introduce the Vodacom Mobile Education Programme. This programme enabled

teachers throughout the country to use mobile technologies and access information to enhance their teaching practice (Department of Basic Education, 2011). The programme focused mostly on mathematics and physical science as they are perceived to be difficult subjects. The main purpose was to help the DBE meet its aim to ensure that the majority of learners were exposed to technology (Education, 2011). Furthermore, it is to enhance the quality of teaching and to ensure that teachers and learners have access to quality teaching and learning aids.

The majority of South African teachers do have basic computer skills and are at initial stage (Meyer & Gent, 2016). They do lack self-confidence with the new technologies and are resistant to implement them to improve teaching and learning. The South African schools according to PanAf (2008-2011) revealed that many of them were unable to prepare lessons and classwork activities using technology (Ndlovu & Lawrence, 2012).

2.4. SOUTH AFRICAN POLICY ON ICT

A policy is defined as a course of action adopted by a person or government. It is a prerequisite for all educational systems to have a national ICT policy (Nicol, 2003). ICT policy suggests that both the departments of Basic Education and Higher Education and Training support actions and processes that are being taken by ensuring that technology is integrated in schools to improve the education system (Mdlongwa, 2012). Policy development on ICT and the formation of Technology Learning initiatives (TELI) started in 1995 (Isaac, 2007). The Department of Basic Education and Department of Communication worked cooperatively to release a strategy for ICT in 2001 (Isaac, 2007). It was understood that it has set the foundation for the e-education White Paper that was approved in 2004. The purpose of developing policy was that all learners should be ICT skilled. In addition, schools were required to be transformed into e-schools that consist of teachers and learners (Department of Education, 2004a). The existing ICT policy in South Africa has been surfacing from 1996 and is rooted within a national government, socio-economic and cultural environment and strategies which contain the following (Isaac, 2007);

- The implementation of ICT at the highest government level to be given attention in order to promote socio-economic growth, creation of jobs and to be able to compete globally.

- The strategy of South Africa and wider Pan-African mandate to be linked as stated in the commitment to New Partnership for Africa's Development (NEPAD) programme.
- To transform education and skills development at various levels.

2.5. PAPERLESS CLASSROOM IN GAUTENG

Paperless classroom refers to the integration of technology (smart boards, tablets, laptops, projectors) in the classroom to eradicate the use of paper, ink and clutter (Carley, 2013). The classroom is completely cloud based. Paperless classroom reduces the amount of paper used in the coursework, resource materials, teaching aids and assignments. Tablets do support many aspects of a paperless classroom for both teachers and learners. Technology becomes an integral part of the classroom environment. The implementation of technology in the classroom has seen teaching being conducted entirely electronically in what is now called paperless classroom. Paperless classroom has shown an increase in productivity and competence for teachers and learners, yet increasing participation (Runnels & Rutson-Griffths, 2013). Computer network and internet resources are also helping teachers cut down on the amount of paper. A paperless classroom offers learners an interactive, resource-filled platform that also strengthens practical skills (Edudemic, 2014).

The GDE embarked on the rollout of paperless classrooms during the year 2015. The aim of this project was to encourage the implementation of ICT, skills development and improving the quality of education in township schools. Seven schools were identified by the Member of the Executive Council (MEC) for Education in the pilot phase of this project (News24, 2015). The initiative was championed by the DBE to enable the South African system to progress to a level of global competitiveness (News24, 2015). Currently, all the Grade 12s in township schools are included in the project. The department is now rolling out this initiative to the Grade 11s and to those schools that achieved a 100% matric pass. The GDE's paperless classroom initiative provides tablets to learners and laptops to teachers, access to online education content and classrooms that are equipped with smart boards and internet connectivity.

2.6. INTERNATIONAL IMPLEMENTATION OF ICT IN EDUCATION

The introduction of mobile technologies has increased over the past years (May & Middleton, 2013). The Canadian Wireless Telecommunications Association says that wireless carriers in Canada provide coverage to many citizens, whereas the joint number of subscriber exceeded 26 million with estimation that almost all citizens will have wireless technologies (Tsinakos, 2013). The President and CEO of the CWTA, Bernard Lord also mentioned that wireless penetration in Canada is set to go beyond 100% in the following years (May & Middleton, 2013). Students in all grade levels agreed that tablets make learning more fun, help them do better in school and customise their learning experience. If the teachers are well equipped with knowledge, they can easily tap into these technology devices as other means of creating and engaging in a learning environment.

Many learners are connected through smartphones and tablets. There are numerous apps, such as POLL EVERYWHERE or SOCRATIVE that can be used to measure the entire class' current level of subject matter comprehension (Giorgi, Sanders, & Soriano, 2015). Educators no longer hand out pop quizzes and manually grade them. They simply poll and instantly review results and utilise class time to fill in the gaps. They also use quick response (QR) codes. QR codes can provide an engaging and active learning experience (Ali, Santos, & Areepattamannil, 2017). Educators also use video conferencing apps such as Skype to help learners become competent global learners. These technologies are used to teach learners about other cultures or take foreign language pen pals to a new level. Learners can also be assigned to conduct a video interview with a scientist, historian or author rather than doing a book report (Ali et al., 2017). Using online access, smart phones and tablets afford learners the opportunity to make the most of every minute. They can perhaps watch an instructional video, conduct some research or perfect their mathematics skills with an interactive game (Ali et al., 2017).

2.6.1. ICT use in East African schools

According to Kimenyi and Kibe (2014), East Africa is making considerable progress in an effort to integrate ICT in five countries, namely; Burundi, Kenya, Rwanda, Tanzania and Uganda.

These countries have developed their own policies and strategies to support the use of ICT in schools. The policies and strategies mainly emphasise the curriculum and professional development. East African governments stress the development of teacher skills and pedagogy as key to successfully implementing curricula. The curricula include the integration of technology to improve teaching and learning and to increase educational standards. The policies and strategies on implementing ICT into education led the governments of these countries to increase their investments in ICT. The countries focused more on secondary school education, excluding Tanzania that implemented ICT in primary schools. There is an increase in availability of ICT facilities in East African schools and connectivity is improving, particularly in urban areas through wireless networks (Nirmala, Tesfazghi, Appalabatla, & Karthikeyan, 2013). In addition, the use of mobile phone technology is extensive and some countries are developing e-content to be used across the curriculum (Hennessy et al., 2010).

2.6.2. Barriers to ICT use in East African schools

Hennessy et al. (2010) state that there are several main factors delaying the implementation of technology by teachers and students in East African schools, mostly in the villages. These include physical, cultural, socio-economic and educational factors. For example, some of the factors are lack of electricity, poor technology infrastructure and congested computer laboratories, high cost of internet connectivity, software licenses and maintenance. Lack of competitive telecommunication policy and guidelines could hinder connectivity and stability (Nirmala et al., 2013). Negative attitude among principals and School Governing Bodies towards technologies and internet impede prioritisation of ICT implementation (Hennessy & Onguko, 2009). The integration of ICT in schools require teachers who are ICT trained, as the ICT skills would give them confidence and make their use of technology in the classroom easy.

2.6.3. ICT national policy in East African schools

The ICT national policy was designed to support learning in schools in Kenya, Tanzania, Uganda, Rwanda and Burundi. The policy starts with a historical situation of the ICT policy of each country and the rationale for their development in education (Farrell & Isaacs, 2007). ICT

policy is provided to schools and if individual schools do not adopt it, then classroom innovations would not be sustained.

In East Africa, education was mostly influenced by the development of technology. The development of ICT policy for implementation in education is important because technology is influential in preparing students in schools for the world of work (Hennessy et al., 2010). ICT facilitates the achievement of life skills that support the development process in the prevailing economic and information order. The development of ICT policy in the East African Community started in the early 2000s. The first ICT policy was comprehensive and involved all units of the education system (Farrell & Isaacs, 2007). It is exciting and motivating to note the manner in which the governments of East Africa emphasise further development of teachers and improvement of their educational skills. The policy points to a desire for a national coordinated effort to create, distribute and share e-lessons to enhance excellence in teaching and learning in schools (Hennessy et al., 2010). In addition, the policy provides for the management and maintenance of the ICT infrastructure and its use in school management (Hennessy et al., 2010).

2.6.4. The integration of ICT in Singapore

In Singapore, the education managers promote the implementation of technology to enhance teaching and learning (Yoong et al., 2009). Singapore developed the master plan of the information technology for the period 1997 to 2002. This was the first stage during which they trained their teachers in the use of technology (Koh & Lee, 2008). The aim of the education authorities in developing the master plan was to make sure that all students had access to technology (Yoong et al., 2009). The second stage of the master plan was aimed at strengthening the integration of ICT into the curriculum and professional development to shape school environments that are acceptable and inclusive (Koh & Lee, 2008).

The use of technology impacts on the students' ability to solve problems as it enhances their understanding of statistical graphs. Students are able to analyse and solve different equations as demonstrated (Ang, 2006). According to Leng and Hoong (2009), the students can easily

view the portrayal as the solution in graphical solution by using graphing software. Leng and Hoong, (2009) pronounce that the integration of hand-held graphing calculators in teaching helps to transform graphs and sketch polar curves. Graphing calculators assist students to understand the changes of the pattern and the graphs' features.

Mobile phones and tablet devices are used to demonstrate how the aid of relevant software can assist the teacher to enhance mathematics teaching and solve mathematics problems. The practices of ICT are piloted chronologically by making numerous experiments to enhance the achievement scores of students. Leng and Hoong (2009) used logo software learning angle concepts in a primary school. The results was that the experimental class was capable of doing the whole examination in two out of three activities without loss in performance (Wong & Lee, 2011). There was also an investigation about LiveMath (a type of computer algebra system) which uses algebraic operations and shows the changes in functional values graphically (Wong & Lee, 2011). Ong (2002) did the study with Sketchpad, which was aimed at geometrical results and theorems (Wong & Lee, 2011).

2.6.5. Mobile learning implementation in Canada

According to the Canadian Wireless Telecommunications Association (CWTA), the majority of Canadians receive Canada's wireless carriers. In fact, the joint subscriber numbers exceeded 26 million with the estimation that more than 30 million Canadians will have wireless devices (Tsinakos, 2013). The President and CEO of the CWTA, Bernard Lord, says that wireless penetration in Canada will go beyond 100% in the following few years (May & Middleton, 2013). There are several learning projects piloted in Canada, which is approved by educational institutions and the provinces. The province of Ontario has passed a law that requires students with special needs to use assistive technology. In addition, Alberta province is developing a guideline on the effective integration of mobile technologies in schools (Fritsch & Wolf, 2012a) The Manitoba's Literacy through ICT Across the Curriculum initiative state that the teachers must develop students' ability to think critically, innovatively and morally through ICT (Fritsch & Wolf, 2012b). Most of these mobile learning projects conducted by universities are contained in the recent report (Ally & Palalas, 2013). This report tried to identify how Canada was placed

worldwide in terms of mobile learning. It is alleged that George Brown College adopted the implementation of mobile technologies following the Bring Your Own Device (BYOD) model. The purpose of the project was to reinforce interactions for English as Language practice and Communication classes (Tsinakos, 2013) and to provide language practice outside the college (Palalas, 2010). At the University of British Columbia, as indicated by Macdonald and Chiu (2011), the implementation of mobile technologies to deliver e-learning was yielded increased convenience and flexibility of the students. This concluded that the most successful way of offering e-content is through video, followed by audio and text (Macdonald & Chiu, 2011). At Algonquin College, students bring their mobile devices and this trend is growing at a rapid rate.

2.7. GENERAL OVERVIEW OF MATHEMATICS TEACHING AND LEARNING IN SOUTH AFRICA

The Constitution of South Africa in Act 108 provides a foundation for curriculum transformation and development to allow education to move forward as one nation (Dalton, Mckenzie, & Kahonde, 2012). Post 1994, the new government of national unity wanted a new national curriculum to be introduced. The purpose was to promote the new constitution, rebuild a divided nation and offer equal education for all. This led to the curriculum being switched from the Outcome Based Education (OBE) to the Revised National Curriculum Statement (RNCS), the National Curriculum Statement (NCS) and presently the Curriculum and Assessment Policy Statement (CAPS). According to the DoE (CAPS 2011), the general aim for mathematics teaching and learning is to develop the learner in the following areas:

- An awareness of the way mathematics relationships are used in socio-economic and cultural relations.
- To confront all mathematical situations with self-confidence and compete without any fear of mathematics.
- To appreciate mathematics.
- To be inquisitive and have interest in mathematics.
- To recognise mathematics as a creation part of social and human activity.
- To have a theoretical understanding and make sense of mathematics.

Mathematics is considered as an important subject in South Africa. Mathematics skills and knowledge are seen as key factors to boost the economic growth of a country. Learners who achieve better results in high school meet the requirements to study further at the university. It is increasingly becoming part of the access requirements to enrol for many degree programmes at tertiary institutions (Sepeng, 2014). However, there are many learners who perceive mathematics as a difficult subject. South Africa is said to be underperforming considerably in mathematics teaching and learning. Mathematics teaching is perceived as very low quality, and teachers as being unable to answer simple questions related to the curriculum (Sepeng, 2014).

The Department of Basic Education's Annual National Assessment (ANA) results for 2012, 2013 and 2014 revealed that the average percentage mark for mathematics were very low in Grade 9. The analysis of the responses showed that learners were unfamiliar with the mathematical terminology, could not grasp basic skills and were unable to solve problems in Geometry (Department of Basic Education, 2014b). Amongst the 21 under-privileged countries that took part in mathematics competition in 2011, the Trends in International Mathematics and Science Study (TIMSS) revealed that South African learners had the lowest performance (McCarthy & Oliphant, 2013). These results have led the government to accept that our education system needs intervention immediately.

2.7.1. Mathematics teaching and learning

Teachers' perception about mathematics teaching and learning using technology are perceived to be vital because they could stimulate teaching and learning (Lin, 2008). Mathematics teachers are also challenged with inhibiting factors or barriers to the use of technology (Pia, 2015). The lack of technology integration is caused by the lack of experience and insufficient training and support. The most common barrier to technology integration in the classroom is lack of professional development and access to computers (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012).

2.7.2. Mathematics enhances memory

Memory is described as a process to recall information. Mathematics needs to be learned with understanding, so that information that is connected can be remembered for a longer period (Sapire, 2007). Information that is connected also provides a whole network of ideas (Unisa, 2006). If the learner is struggling to remember some information, ideas that are connected can usually lead him or her to the required answer. It is sometimes difficult to retrieve disconnected information.

2.7.3. Mathematics improves attitudes and beliefs

The relational understanding can stimulate a positive feeling and instil confidence in the learner (Sapire, 2007). Relational understanding is having a mathematical rule, knowing how to use it and knowing how it works. It simply means knowing and applying the rule while also being able to know why a rule works. It also promotes the ability of the learner to observe and reason constructively. The learner is likely to develop a positive self-confidence with regard to his or her ability to learn, understand and appreciate mathematics, once learning relationally (Sapire, 2007). Learners make findings, share their experiences with their peers and participate in productive discussions about the approaches and solutions to the problems.

2.8. THEORETICAL FRAMEWORK

This section presents an indication of appropriate variables that are linked to the implementation of technology. In Technology Acceptance Model (TAM) theory, there are several appropriate variables that affect users in implementing technology. They are perceived usefulness (PU) and perceived ease of use (PEOU). Actual system use (ASU) is also an important variable in clarifying the decision to implement technology.

2.8.1. Background

The study will draw on the theoretical framework called the TAM developed by Davis in 1989. This model is an information system theory that models the acceptance of the use and integration of technology. It is claimed to be a recognised framework linked to technology acceptance, firstly proposed by Davis (1989) and has been confirmed as a theoretical model that helps to describe and predict use and behaviour of technology (Park, 2009). It is further seen as a powerful extension of the theory of reasoned action (TRA) (Surendran, 2012). The TAM is used to explain user acceptance of an online service portal. He wanted to draw some implications for the practitioners about how to adapt the design of system characteristics in order to improve user acceptance. The TAM specifies PU and PEOU as the two main influences of system use (Hartmann, Kerssenfischer, Fritsch, & Nguyen, 2013). Perceived usefulness is defined as an indicator for the extent of job performance improvement perceived by a person who applies a new system (Vendekatesh & Davis, 2000).

2.8.2. The development of the TAM

In the 1970s, institutions saw an increase in technology needs and implementation of the information technology system. Many researchers developed an interest in this field to predict which system to use for their research. However, studies did not yield reliable methods that could explain which system was accepted or rejected. Davis (1989) proposed that system use is a reaction that could be explained or predicted by user motivation.

Many researchers are using TAM to understand the connection between people and technology through perceived usefulness (PU) and perceived ease of use (PEOU) (Olumide, 2016). TAM was adopted in this research to present a foundation to ascertain the impact of external variables on personal beliefs, skills, attitude and intention to use (Olumide, 2016). It disseminates stages that information seekers will follow to accept and utilise the smart boards and tablet devices for teaching and learning. Also, it evaluates the main variables for using smart boards and tablets for teaching and learning. Figure 2.2 shows the original TAM by Davis, 1989.

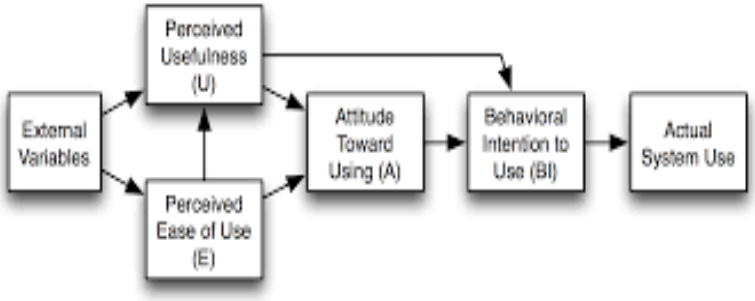

Figure 2. 2: Original Technology Acceptance Model

(Source: Davis, 1989)

2.8.3. External variables

It is confirmed that there are many external variables that are part of the TAM and could be an indicator to procedures that need to be followed in integrating smart boards and tablets in the classroom (Winarto, 2011). These variables were identified and popularised to explain the process that the participants should go through in acquiring new skills.

It was suggested that PU and PEOU predict learner attitudes and that PEOU predicts PU (Cheung & Vogel, 2013). Some studies also suggested PEOU and PU were found to be important measures for learner attitudes toward the implementation of technology in education (Edmunds, Thorpe, & Conole, 2012). Variables that are related to the behavioural intention to use technology are listed into different categories showed in Table 2.2. These variables are school, system, teacher and learner and social variables. Despite the fact that social background means social influence on personal acceptance of technology use, school environment emphasises the school's influence on teachers and learners' use of technology (Park, 2009). System visibility, system accessibility and relevance were identified as school context variables. In this study, school context affects both PU and PEOU of the implementation of technology in teaching and learning. The table below classifies the variables into four categories.

System, teacher and learner characteristics were added as variables that were assumed to influence PEOU and the use of an e-learning system (Pituch & Lee, 2006). Vendekatesh and Davis (2000) came up with a new type of TAM called TAM2 which supplemented THE existing model with new variables. TAM was also adapted by adding the difference of compatibility (Agarwal & Prasad, 1998). In 2001, Moon and Kim also introduced another variable that included playfulness factors to study acceptance of the world-wide-web (Surendran, 2012). Lim (2001) adapted TAM and added extra variables that include experience, self-worth, perceived risk and social influence (Surendran, 2012). The factor of peer influence was combined with TAM (Chau & Hu, 2001). Chau and Hu (2001) further maintained that the participation of students at university in effective e-learning systems was important and thus students' acceptance behaviour should be evaluated (Saade, Nebebe, & Tan, 2007). They recommended that TAM should be a solid theoretical model and its validity should be extended to the e-learning context.

Table 2. 2: Variance of External Variables

(Source: Winarto, 2011)

School's Characteristics	System Characteristics	Teacher and Learner's Characteristics	Social Variables
Competitive environment	Design	Age	Cultural empathy
Teacher and learner support	Operation	Ability to reason	External influence
Internal training	Maintenance	Information anxiety	Facilitating condition
School Management Team influence	Development	Technophobia	Subjective norm
Adoption of policy	Audit	Technology skill	Influence of peers
Structure of the school	Access control	Educational level	Social influence
Influence by peer	Interface	Knowledge	Change
Development of training	Convenience	Sex	
	User openness	Self-inspiration	
	Quality of data	Character	
	System quality	Perceived enjoyment	
	Cyber security	Perceived playfulness	
		Self-efficacy	

2.8.4. Perceived Usefulness (PU)

Perceived usefulness is described as the level to which a person believes that using a specific system would improve job performance (Davis, 1989). Accessing information provide the opportunity for enhanced human competence (Lombardi, 2007). The ability to access accurate data is negatively impacted by users' unwillingness to adopt the methods that are helpful to access the information (Lombardi, 2007). Jahangir and Begum (2008) describe perceived usefulness as the extent to which an individual thinks applying a certain method could improve job performance. Davis (1989) also believes that people are usually rewarded for performing better by promotions and bonuses (Olumide, 2016).

2.8.5. Perceived Ease Of Use (PEOU)

Perceived ease of use refers to an extent that an individual thinks that using a specific system could be free from effort and provide freedom from difficulty (Davis, 1989). Many people usually adopt and implement an application that is perceived to be easy to use. PEOU refers to the level that a person acknowledges that using a specific technology would be free from effort (Olumide, 2016). TAM was integrated with a theory that emphasises concentration on the structural model (Liu, Liao, & Peng, 2005). Liu, Liao and Peng (2005) claimed that users of e-learning at the university must be viewed as both system users and students.

2.8.6. Attitude towards using technology

The attitudes towards using technology are projected from two factors which represent use of beliefs and attitude, PU and PEOU (Park, 2009). Attitude refers to positive or negative behaviour of a person towards adjustment to change and innovation. Banaji and Greenwald (1995) describe attitude as a hidden drive-producing response that is considered important in the social environment of a person. In addition, attitude is defined as a belief of an individual about the consequences of a particular behaviour and his or her assessment of those consequences (Greenwald & Banaji, 1995). Attitude is also described as a positive or negative feeling of a person linked with performing specific behaviour (Mun, Jackson, Park, & Probst, 2006). The attitudes and beliefs of the participants towards the use of technology in the classroom influence the implementation of technology.

2.8.7. Behavioural intention to use technology

Behavioural intention to use technology was emphasised within the institution, individuals create intentions toward behaviours which they think may enhance job performance (Davis, 1989). Park (2009) says that the technology acceptance model could help predict acceptance, but does not regularly help realise and clarify acceptance beyond assigning the system characteristics of PEOU and PU.

2.9. CONCLUSION

ICT is integrated along with other technologies in the classroom. After probing the literature that has been studied, the researcher needs to acknowledge that ICT provides the potential to meaningfully enrich instruction. Technology has not been fully implemented, because teachers and learners are confronted with several problems. This chapter briefly enlightened the various technology implementations in East African countries, the use of ICT in mathematics education in Singapore, mathematics teaching and learning in South Africa and national policy for ICT use to enhance teaching and learning in East Africa. The next chapter unpacks the research process followed during investigation into the implementation of technology in two schools in the South African context.

CHAPTER 3: METHODOLOGY

3.1. INTRODUCTION

This chapter begins by outlining the research methodology followed by underpinning qualitative research to explore and describe the paperless classroom experiences and implementation of technology in teaching and learning of mathematics. Research methodology involves the methods and processes intended to collect data. In addition the chapter discusses the philosophical assumptions, approach, strategy and data collection used. The strategy used is a multiple case study that will be analysed through qualitative method. Lesson observations, interviews and focus group interviews will be used for collecting data.

3.2. RESEARCH QUESTION

There are a number of research questions that were formulated from the general aims of this study. **The primary research question is:**

RQ. How can the experiences of teachers and learners in Grade 7 mathematics in township schools inform further rollout of paperless classrooms?

Secondary research questions:

SQ 1. How do teachers use smart boards and tablets in Grade 7 mathematics classrooms?

SQ 2. What are the problems confronted by teachers and learners when using the technology in teaching and learning of mathematics?

SQ 3. What are the positive experiences acknowledged by both teachers and learners when using technology in teaching and learning?

3.3. RESEARCH DESIGN

Research design provides a complete framework for the process of the research (Leedy & Ormrod, 2013). It is a design that is used to select participants, research sites and the processes for collecting data to investigate the research questions (McMillan & Schumacher, 2010). A design is an outline that links a connection between research questions and the strategy to be implemented (Leedy & Ormrod, 2013). Welman, Kruger and Mitchel (2011) describe it as the overall plan which is used to choose the participants of a research study and the methods of data collection while Babbie and Mouton (2003) define it as a blueprint that is used to conduct research and provides a brief overview of the main issues to be considered.
The research onion developed by M. Saunders et al. (2007) was implemented to give this study direction. The onion shows various choices, paradigms, strategies and steps that will be followed by the researcher during investigation as shown in Figure 3.1. There are different layers in the onion that are used as a foundation from which the researcher will consider various topics, namely; philosophy, approach, strategy, time horizon and data collection methods.

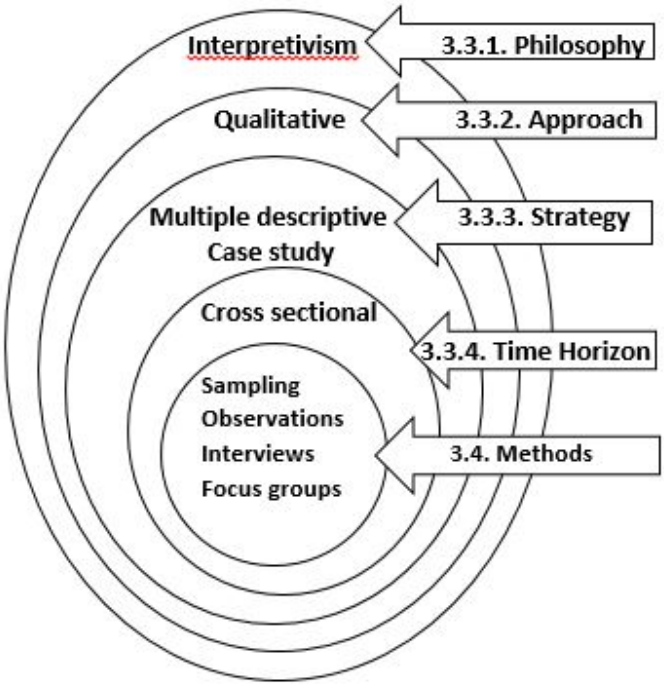

Figure 3. 1: Adapted research onion
(Source: Saunders, Lewis & Thornhill, 2007)

The research design is unpacked in the following section.

3.3.1. Philosophy: Interpretivism

Philosophy is defined as a belief that data about a phenomenon should be collected, analysed and implemented. It is also referred as a framework that includes opinions and understanding of a number of theories and practices that are used for investigation (Cohen, Manion, & Morrison, 2007). Interpretivism was identified as a philosophy for this study. Interpretivism was also guided by hermeneutics and phenomenology. Phenomenology is based on the need to consider individuals, subjective interpretations and how they see the world in understanding the social phenomena (Cohen et al., 2007). According to McGregor & Murname (2010), the interpretivists implement a specific approach to interpretation. They make assumptions about data and meaning as being acts of interpretation. Therefore objective knowledge is not free of thinking people who reason, whereas Myers (2013) claims that the interpretivists' belief is that reality can be accessed through language and shared meaning.

Antwi and Hamza (2015) say that, "interpretivists believe that the reality that consist of people's subjective experiences of external world; thus, they may adopt an inter-subjective epistemology and the ontology that reality is socially constructed." They believe that there is no particular correct method to acquire knowledge. Interpretivism is supported by observing and interpreting, collecting data about the events and deriving significance from that data. (Antwi & Hamza, 2015).

The findings of the study satisfies the framework of the interpretivist that allows the discovery of multiple realities and methods to experience the same occurrence. Knowledge is therefore socially constructed by every participant with own situations and opinions to create multiple realities (Thomas, 2010). Every participant is seen as an individual with his or her own understanding and approach. The researcher believes that in order to understand any phenomenon, it must be observed in its natural setting. Hence, the researcher chose to engage the phenomenon to understand the impact on those interacting with it.

This study is supported by interpretivist perspective because of its interest in each participant's own teaching and learning experiences. The two schools mentioned in this study differ with regard to their technology implementation, skills and knowledge. The teachers' knowledge and skills of integrating smart boards and tablets will not be the same. In order to achieve the integrity of the phenomena being investigated, the researcher made efforts to observe the lessons and interview the participants to understand the actions from within.

3.3.2. Approach: Qualitative

The approach refers to a plan to investigate and move from underlying assumptions to design and collection of data (Myers, 2013). It was developed to allow the researcher to explore social and cultural phenomena (De Vaus, 2001). It provides in-depth understanding of the social world, depending on a small sample, and uses observation, interviews and focus groups methods to collect data (Cohen, Manion, & Morrison, 2011).

This approach is illustrated in the second layer of the research onion in Figure 3.1. The study has focused on a qualitative approach as it offered flexibility and robustness. The approach allowed the researcher to investigate the implementation of technology over time, yet it allowed investigation and interpretation of classroom incidents. In addition, this approach is intended to provide the researcher with the perception of a particular group – which is the Grade 7 mathematics teachers and learners (Wiliams, 2007). The researcher is required to avoid imposing his own perceptions about the use of technology in the classroom upon the participants (Banister et al., 2011). The aim was to investigate how the participants engaged in the implementation of smart boards and tablets in teaching and learning. The research methods of the qualitative approach assisted the researcher to realise the implications that the participants attached to social phenomena. In a qualitative approach, the researcher becomes the instrument of data collection. In qualitative research, data collection methods are used to produce in-depth data that leave the perceptions of the respondents complete and provide a background for human behaviour (Sampathirao, 2016). The researcher physically went to the participants' natural settings which in this case are the two primary schools to collect data about their experiences of how they are implementing smart boards and tablets in teaching and

learning. The qualitative researcher investigates the participants in their setting and interprets the occurrences, attitude and behaviour in relation to the meanings that they bring. This approach has assisted the researcher to obtain rich and detailed understanding from the participants' experiences of paperless classroom.

Table 3. 1: Comparison of quantitative and qualitative research approach (Source: Cresswell, 2014)

Orientation	Quantitative	Qualitative
Objective	To quantify variation	To describe variation
Assumption about the world	A single reality	Multiple realities
Researcher's purpose	Create connections between measured variables.	Understand the events from respondents' perception.
Methods	Structured method is applied	Semi-structured method is applied
Questioning	Objective	Subjective
Data format	Numbers and statistics	Language and textual
Researcher's role	Objective – seeks accuracy	Subjective – individual interpretation of events
Research methods	Deductive	Inductive
Generalisability	Universal context-free generalisation	Detailed context-based generalisation

Table 3.1 above distinguishes between quantitative and qualitative approaches. In a qualitative approach, the researcher is regarded as the main instrument of collection of data. The researcher is involved in the situation and makes sense of multiple realities. The multiple realities exist in a given setting as the researcher and the participants create their own realities. The researcher avoids interfering and imposing his perception when collecting data, hence he attempts to investigate real-world situations as they unfold naturally.

The aim of the researcher was to understand the real sense that participants give to the events as they unfold. Sources of data come from completion of observation of events, interviews and focus groups discussion. Theoretical assumptions are then supported by the inductive method.

The results were summarised in relation to existing knowledge, and the aim was to demonstrate the way in which the study has contributed to cumulative knowledge. Qualitative research acknowledges that the researcher is subjective, but also requires that the researcher's prejudices and interests be identified and made clear throughout the study. In qualitative research, the results must be based on whether the research is trustworthy, rather than enforcing quantitative ideas of generalisation on qualitative research (Thomas, 2011).

3.3.3. Strategy: Multiple case study

3.3.3.1. Case study strategy

This study used a case study approach as a strategy to investigate paperless classroom experiences in teaching and learning of Grade 7 mathematics in two schools. A case study includes a practical enquiry about the implementation of ICT in its setting by using multiple sources of evidences (Cohen et al., 2007). Furthermore, the study used the case study to examine the experiences of both teachers and learners in using technology resources in the classroom. During this process, the study employed various sources of data in the classroom which are observation, interviews and focus group interviews (McMillan & Schumacher, 2010). In the classroom, information was collected as evidence and was later analysed to see whether it answered the research question. As a result, these answers may make the researcher understand how technology impacts teaching and learning and whether there is a need for further research to close gaps left by this study.

The case study provides a unique example of actual participants in a natural setting to enable the researcher to understand ideas clearly (Cohen et al., 2011). Furthermore, it provides the opportunity to explain why certain results may happen, rather than just finding out about those results. The case study is useful to disclose the causal relationships between the phenomenon and the setting in which it takes place (Cresswell, 2014). The case study is regarded as the appropriate strategy to use, owing to the interpretive position implemented in the study and the nature of the research question. It offers an organised way to collect qualitative data, understand a particular situation in detail and examine integration of technology in a natural

setting (Thomas, 2010). The use of a multiple case study often provides data that can be compared and referred to as comparative case studies (Yin, 2003). The use of a multiple case study gives the researcher the opportunity to analyse the differences between each case (Baxter & Jack, 2008). For this study, each case that formed part of the multiple studies was situated within its own unique educational setting, that is, the teacher and learners' access to tablets and the school's demographic situation. The use of tablets differed from one school to the other, which added to the depth of the data collected and also provided possible patterns for the manner in which tablets were used in each context.

Table 3.2 below shows a classification of different types of case studies. Yin (1993) used various case studies, namely; exploratory, causal and descriptive. Descriptive case study refers to a brief overview of an existing phenomenon and use figures or labels to characterise the participants. It assesses the nature of existing conditions' which is the implementation of technology in the classrooms for the two sampled schools. There can be several case studies according to the number of participants. Descriptive case study was used in this study to describe the occurrences and attitudes of the teachers and learners on the implementation of ICT in the classroom.

Table 3. 2: Types of case studies

Criteria	Types of case study	Application
Nature of the case	Intrinsic Instrumental Collective	Focus on specific events in natural settings Provides an insight Extends to numerous instances
Theoretical aims	Descriptive Causal Exploratory	Describing variables Looks for cause-and-effect relationships Acquiring new insights
Number	Single Multiple	Can often be used to pursue explanatory research Strengthening the results
Units	Rooted All-inclusive	

3.3.3.2. Descriptive case study

Descriptive case study is defined as a scientific method that includes observation and description of the behaviour of the participant without manipulating it in any way. Data is collected without manipulating the environment. Descriptive case study is used to collect data about the existing level of the phenomena to describe “what exists” with respect to variables in a situation. Qualitative researchers usually analyse their data inductively, thus moving from specific data to general categories. The researcher uses descriptive and interpretive case studies to analyse, interpret and theorise the phenomenon being investigated. This type of research simply describes the attitudes, behaviours, achievements or other traits of the participants. It reports events the way they are or were. This research investigates the nature of a classroom environment and its relationship to the participants’ attitudes and behaviour when using smart boards and tablets for teaching and learning.

3.3.3.3. Case context

The two primary schools were identified. They form part of the seven schools chosen by the Gauteng MEC for education to pilot paperless classroom which started in January 2015 in the Gauteng province (News24, 2015). They are both township schools in the Gauteng province. The schools’ infrastructure has been upgraded and they have been equipped with the latest technology in all Grade 7 classrooms. The smart boards and data projectors have been installed in the classrooms and teachers provided with laptops whereas learners received tablets. The project is funded and supported by the Gauteng Department of Education. They have security personnel which is also paid by the GDE patrolling the school premises day and night to safe-guard the technology devices.

Learners’ tablets are retrieved at the end of each year for safe keeping and to be flushed and installed with new e-books for the following year. The schools also have strong Wi-Fi connection which covers the whole school grounds to allow teachers and learners access to online educational content. Teachers have been trained and are still receiving training on the usage of smart board for teaching and learning. GDE has appointed service providers to provide

training and support. Each school has been allocated interns who are stationed at school on a full time basis to provide technical support.

3.3.3.4. Geographical background of the schools

Learners in both schools come from the same disadvantaged socio-economic background. They are in the same township and the schools are close to each other. Most of the learners walk to school and only a few of them travel by their own transport. The schools are no fee paying schools and rely on resource allocation funds to buy Learning and Teaching Support Materials and maintain their infrastructure. Most of the parents are dependent on social grants since they are unemployed. The language of teaching and learning in both cases is English, although the Home Language is Sepedi.

3.3.3.5. E-content

The schools are provided with e-textbooks. The licences of e-books that are installed in the smart boards and tablets are paid for by the GDE with the money deducted from the schools` resource allocation funds. The schools are responsible for profiling the textbooks of their own choice and sending the list to the head office which will do the final procurement.

3.3.3.6. The service provider

Matthew Goniwe School of Leadership and Governance (MGSLG) has been appointed as the main training and development arm for the GDE. MGSLG's mandate include Teacher Development, Parental and Community Support Programmes and the development and implementation of programmes such as ICT in schools. All the support, training and development programmes conducted by MGSLG are being aligned with and in response to the main priorities of the GDE.

3.3.3.7. Case descriptions

Case A

This school is also sponsored by Vodacom and has been provided with Samsung tablets devices. The Grade 7 learners have two sets of tablets, the ones provided by GDE and another set donated by Vodacom. They are both kept at school in the storage room for safe keeping and charging overnight. The school has a functional computer laboratory and Wi-Fi installed by its sponsor.

Figure 3. 2: Case A Storage for tablets

The learners' tablets are stored in a locked trolley for safe keeping as shown in Figure 3.2. Learners are not allowed to take the tablets home. The tablets are distributed in the morning and collected at the end of the school day. The trolley is taken to the strong room where the tablets are charged overnight.

The school's sponsor also organises training and workshops for all the teachers to develop them with the skills to be able to use the technology devices in the classroom. The school also has several young teachers who are actively involved in the implementation of technology in

the classroom. The teacher-participant in this school had three years of Grade 7 mathematics teaching experience.

Case B

The school only receives training from the service provider and do not have any sponsor apart from the GDE. They have one set of tablets provided by the GDE. Learners are not allowed to take the tablets home for fear of being robbed on their way. Tablets are handed out to the Grade 7 learners in the morning by the class teacher and retrieved at the end of the day for safe-keeping and charging overnight. The school also has one mathematics teacher who is responsible for teaching all Grade 7 learners. She has been teaching for 16 years and only started using technology in the classroom in 2015 when it was introduced.

Figure 3. 3: Case B Storage for tablets

Figure 3.3 shows how the tablets are stored and charged. In the morning, tablets are taken out of the trolleys and carried to the classrooms in the boxes. The names of the learners are written at the back of the tablets and the teacher will then distribute them accordingly. At the end of school day, they are retrieved and carried back to the ICT room where they will be charged overnight.

3.3.4. Time horizon: cross sectional

Cross-sectional refers to a research strategy in which several different subjects are assessed at the same time (McMillan & Schumacher, 2013). All the data were collected in the second quarter in 2017. The advantage of cross sectional is that it produces the results more quickly and seldom suffers from control effects. It secures cooperation of the participants on a once off basis.

3.3.5. Participants

3.3.5.1. Population

Population refers to a large group of individuals which can be sampled for investigation and from which findings can be generalised (McMillan & Schumacher, 2010). The purpose of qualitative research is to provide a rich, contextualised description of these two cases. It involves all participants with particular specified characteristics. In this study, the participants are all the mathematics teachers and learners in Grade 7 in the two primary schools where technology is implemented.

3.3.5.2. Sampling

According to this method, participants are chosen because of their knowledge and relationships regarding a research subject (Cresswell, 2014). The size of the sample is depended on what the researcher investigates and the aim of the research. In qualitative research, the size of the sample is nor prescribed by specific rules (Patton, 2002).

Purposeful Sampling was used to select the participants. In purposeful sampling, the researcher selects participants with certain characteristics that will be representative and informative about the topic being investigated (McMillan & Schumacher, 2010). Participants were identified and selected as they were knowledgeable and were currently using technology in the classroom. Participants must be willing to engage and communicate their practices and

views meaningfully and reflectively (Etikan, Musa, & Alkassim, 2016). The sample has been selected with a specific purpose, therefore participants are possibly more knowledgeable and informative about the implementation of smart boards and tablets in teaching and learning. The researcher purposefully selected the two primary schools with the view that they are information rich cases as they are currently using technology in the classroom.

Selection of teachers - In this study selected participants have relevant experience in the implementation of technology in the classroom. Within this context, the participants have been selected from the two primary schools which are using tablets and smart boards as a pilot project for teaching and learning. The two Grade 7 teachers are currently teaching mathematics at respective schools.

Purposive selection of learners - Ten learners from each school were selected by the researcher for the focus group discussion. These learners were selected based on their knowledge of technology use, their availability and willingness to participate (Cresswell & Plano Clark, 2011) and their ability to communicate their experiences and ideas meaningfully. They were of the same age group, which is thirteen years.

Table 3. 3: Participants' role and vulnerability status
(Source: The researcher, 2017)

Role	Vulnerability status	Institutional affiliation	Justification for participation
Two Grade 7 mathematics teachers from the two schools	Low	The teachers are teaching in the two respective schools.	They are part of the pilot project and are currently experiencing the use of smart boards and tablets in the classroom.
Grade 7 learners from two primary schools in the township	Low	They are learners in the two primary schools.	Learners are currently using the tablets for learning.

Participants in the two cases are fairly equal and share same similarities as illustrated in Table 3.3. They are both primary schools and learners in Grade 7, of the same age group. All Grade 7 mathematics classes in each school are taught by one teacher. They have been selected because they are part of the project that introduce the implementation of smart boards and tablets in the classroom. It is reported that learners who do not have tablets in case A are new in the school and their names have been submitted to the GDE (ICT unit) so that they can be provided with the tablets.

Table 3. 4: Description of participants
(Source: The researcher, 2017)

Description	Enrolment	Gender	Age	Teacher/Learners with tablets	Teacher/Learners without tablets
Case A learners	46	Boys & girls	12 - 15	38	7
Case B learners	47	Boys & girls	12 - 15	14	33
Case A Mathematics teacher(s)	1	Female	25 – 35	1 teacher laptop	0
Case B Mathematics teacher(s)	1	Female	40 – 50	1 teacher laptop	0

The learners in the two schools were boys and girls of nearly the same age-range as shown in Table 3.4. The teachers were both females and differed with age and teaching experience, although they all started using technology in the classroom in the same year when the project was introduced. Learners who did not have tablets were either new in the school or their tablets were not working. The GDE provided each teacher with a classroom laptop that had lesson plans.

3.3.5.3. Participation summary

Table 3.5 below illustrates participants and the data collection instruments that were used. The researcher collected data from the two schools which were implementing smart boards and

tablets in teaching and learning which addressed the research question, indicated as RQ. It was during this time that the researcher directly interacted with the participants for the duration indicated in Table 3.5. The researcher observed how teachers implemented smart boards and tablets in the classroom. In support of the above table, the researcher took notes during lesson observations, which included what he saw, heard, experienced and thought.

Participants (both teachers and learners) were observed in order to answer SQ1 and SQ2 in Grade 7 mathematics lessons for two periods in each school (Case A and B) as shown in Table 3. They were interviewed at the end of the lesson and learners participated in focus group interviews.

Table 3. 5: Participation summary

Participants	Activities	Venue	Duration
Grade 7 Mathematics Educator 1	Interview	School A	1 x 30 minutes
Grade 7 Mathematics Educator 2	Interview	School B	1 x 30 minutes
Educator and Grade 7 learners	Classroom observation	School A	2 x 30 minutes
Educator and Grade 7 learners	Classroom observation	School B	2 x 30 minutes
Focus groups – 10 learners	(Interview) Focus group	School A	1 x 20 minutes
Focus groups – 10 learners	(Interview) Focus group	School B	1 x 20 minutes

3.4. DATA COLLECTION PROCESS

Data collection refers to the in depth explanation of data gathering methods for the planned investigation (Cohen et al., 2011). The collection of data started when the researcher decided where and how data would be collected. The researcher viewed participants as a source of data and used various data collection instruments as seen in Table 3.5 below, to ensure a thick description of the data collected. The methods that were used to collect data are lesson

observations and semi-structured interviews and focus groups interviews (found in appendices G – I) to develop a detailed description of the phenomenon.

3.4.1. Access to the research site

In order to gain access to the teachers and learners of the two schools, consent was obtained from the Principal (see appendix C), letter of consent from teachers (appendix D), letter of consent from parents (appendix E) and letter of assent from learners (appendix F). The Principal of school A requested the ICT coordinator to assist the researcher to issue and collect all the letters mentioned above from the participants. In case B, the Head of Department assisted the researcher by ensuring that all the participants were well informed about the process, received the letters and returned them.

3.4.2. The researcher's role

In qualitative research, the researcher is the primary instrument through which participants are investigated (Thomas, 2010). The researcher should empathise with respondents and see the world from the subject's perspective. The researcher must also be careful of prejudice since the expectations will lead a researcher not to see some of the data. The researcher should also be knowledgeable about the topic and should know when to encourage the participants to elaborate the topic being investigated.

The researcher spent some initial time doing a briefing and provided clear explanation about the purpose of the research. It was during this time that the researcher directly interacted with the participants and helped them feel at ease. During the discussion process, the researcher was impartial, non-judgmental and avoided giving personal opinions so as not to influence the participants towards a particular opinion. He encouraged the discussion by asking open ended questions and probed for more details with follow up questions. The researcher also made sure that the discussion did not lose focus and remained relevant by maintaining discipline. Although the researcher was a teacher at one of the schools, he did not teach Grade 7 learners. Learners enjoyed being part of the discussion. They felt at ease during the discussion and spoke freely.

The fact that the researcher was working at the school did not bother them, because they participated in many debates in front of their teachers. The study aimed to collect data that reflected honestly on the participants' experiences in using the smart boards and tablets for teaching and learning. During the interview, the interviewer's role was to encourage the respondents to participate without fear. Probing encouraged participants to provide more information. The researcher made sure that probing was impartial to avoid bias. The methods used for probing included:

- Open ended questions

Questions that did not require yes or no but provided participants with sufficient opportunity to share their experiences. Participants were allowed to answer in their own language.

- Tracking

Interviewing is like a needle tracking the grooves of a song. The researcher encouraged respondents to talk by carefully following the subject and meaning of their verbal and non-verbal discussion.

- Clarification

The researcher asked the participants to explain, by asking follow up questions such as "Can you please tell me more about your experience of the implementation of ICT in the teaching and learning of mathematics in your class." The researcher was able to realise if questions have been understood and could explain issues under discussion.

- Reflective summary

The researcher repeated the sentiments of the participants exactly in their own words. The TAM was used as a guideline for the questions that were asked during collection of data.

3.4.3. Data collection instruments

Data collection instruments illustrated in Table 3.6 are described in more detail in the following section. The main purpose of selecting the most suitable data collection instruments was to respond to the research questions formulated during the initial stages of research.

Table 3. 6: Data collection instruments

Data collection instruments	Documentation method
Lesson observations – paragraph 3.5.3.1	Recording of lessons, making field notes and transcribing
Interviews – paragraph 3.5.3.2	Recordings and transcriptions
Focus groups – paragraph 3.5.3.3	Recordings and transcriptions

3.4.3.1. Observation

Observation is a systematic process of taking notes and recording occurrences, behaviour of participants without asking questions or communicating with them (Maree, 2007). The researcher as an observer has collected data using observational methods on how participants use smart board and tablets for teaching and learning. The advantage of observation method is that the researcher can evaluate participants' natural setting indirectly. However, the participants may change their conduct once they realise that they are being observed. The collected data was comprehensive enough to enable the researcher to produce the analysis that was performed.

In this study, the researcher observed four lessons (two in each school) whereby smart boards and tablets were used for teaching and learning. On the first visit to the school, the researcher requested to observe mathematics lessons to see how smart boards and tablets were used in teaching and learning situations. The researcher also asked for the class timetable in order to make arrangements and appointments to observe mathematics teachers. The observation sheet attached in (Appendix G) was used as a method to collect data. Data were recorded using an audio recorder and the researcher also took notes during observation lessons.
The following activities were observed:

- Connection and set up of the smart boards;
- Ability to use functions on the toolbar;
- Actual teaching of the lesson;
- Ability to fix basic troubleshooting;

- Teacher's knowledge and confidence;
- Management of tablets during teaching and learning.

Hoepfl (1997) claims that observation leads to the bottom of the investigation and understanding as it provides knowledge of the occurrences in the natural settings. The researcher is able to see things that the participants are not aware of.

3.4.3.2. Interview

Interview refers to a method of collecting data through oral questioning by means of using semi-structured questions (Thomas, 2010). It is described as a conversation between two or more people where the investigator asks the interviewee questions to learn about the interviewee's views, interpretations and conducts (Maree, 2015). The main advantage of using interviews to collect data is that it allows direct interaction with interviewees and leads to detailed and valuable feedback. The interview method can be unstructured, structured and semi-structured with participants or focus-group, depending on the need and design. For this study, the researcher used semi-structured interviews as discussed in the next paragraph.

Semi-structured interview

The researcher used this method because it has characteristics of both structured and unstructured interviews, hence closed and open-ended questions were used. The interviewer had semi-structured questions as a guide so that the same questions were asked with each participant. This method was used to collect data that the researcher could not obtain during lesson observations. The maintenance of a warm relationship between the researcher and participants is recommended as the interview is an interaction between two or more people (Czarniawska, 2004).

The researcher has interacted with two Grade 7 mathematics teachers and they were asked the same questions on different days (see attached Appendix I for semi-structured interview). The teachers were chosen based on the fact that they used technology in their classrooms to teach mathematics. As participants in the study, the teachers were asked to explain the general

use and acceptance of technology by their colleagues and the concerns of teaching using technology. The interviews with each teacher lasted for less than twenty minutes.

The semi-structured interview method was used to ease the participants' emotions as they were not attacked with questions early during the interview. However, they were asked to provide their opinions concerning the use of smart boards and tablets for teaching and learning. The respondents were able to divulge appropriate information without fear and had the opportunity to explain the fundamental meaning of their answers in detail (Polit & Beck, 2014).

To arrange for the interviews, the researcher followed these steps:

- Made appointment with the teachers;
- Asked to meet in an empty classroom conducive for conversation;
- Structured chairs to allow for face-to-face interview'
- Positioned a cell phone for audio-recording;
- Placed questions ready so that the interview could start (see Appendix I for semi-structured interview questions).

Before the interview began, the researcher

- Thanked the teacher-participant for accepting to take part in the research;
- Informed the participants about the consent letter;
- Clarified to the participants that the interview would be semi-structured and follow up questions would be determined by the responses provided;
- Asked permission to record the interview.

Conducting the interview

The interview started with a general question which was a RQ: "How can the experiences of teachers and learners in Grade 7 mathematics in township schools inform further rollout of paperless classrooms?" Once the interview had started, the researcher's role was to motivate the participants to carry on speaking, by signalling with his head and showing attentiveness. Participants were also motivated to explain their involvement of using technology to learn in detail.

3.4.3.3. Focus group

A focus group is defined as a well-organised discussion intended to obtain opinions about the research topic in a non-frightening environment (Springer, Haas, & Porowski, 2017). It is a meeting in which a researcher takes the lead in a discussion with a group of learners to find out what they think and how they feel about the research topic (Johnson & Christensen, 2017).
In this study, two focus groups (one from each school) consisting of ten learners respectively were interviewed. The number of learners in the groups was sufficient for the researcher to be able to control interaction within the learners, facilitate group dynamics and ensure that each learner had sufficient time to participate in the discussion. Learners were comfortable and enjoyed the group discussion, while sharing their thoughts and experiences on the implementation of technology in the classroom.

The researcher depended on the interaction within the group that discussed the implementation of technology in the classroom to yield collective perceptions. Learners developed and expressed ideas they would not have thought about on their own. They collected data on the attitudes, values and opinions of using technology to learn. Learners were also encouraged to speak in their own language.

3.5. CONCEPTUAL FRAMEWORK

In this section, the conceptual framework was used to explore the issues that affected the Grade 7 mathematics participants' use of technology in the classroom. TAM appeared to be a suitable model for understanding conceptual issues in the use of technology. It is claimed that the effectiveness of this model can be controlled by the acceptance of the user. The user acceptance is controlled by perceived usefulness (PU), perceived ease of use (PEOU) and attitude towards use (ATU) of the system (Shroff, Deneen, & Ng, 2011). There were a number of external variables (EV) that could affect PU and PEOU. PU and PEOU are regarded as cognitive factors whereas ATU represents participants' positive and negative feelings when a particular behaviour is displayed (Shroff et al., 2011). In order to develop the conceptual framework, factors that affect teachers' use of technology in teaching should be identified. The

different stages of technology acceptance are presented in the form of a flow diagram in Figure 3.4 below. These stages begin with external variables that influence PEOU and PU of technology leading to ATU and BIU (behavioural intention to use) resulting in ASU (actual system use) of technology.

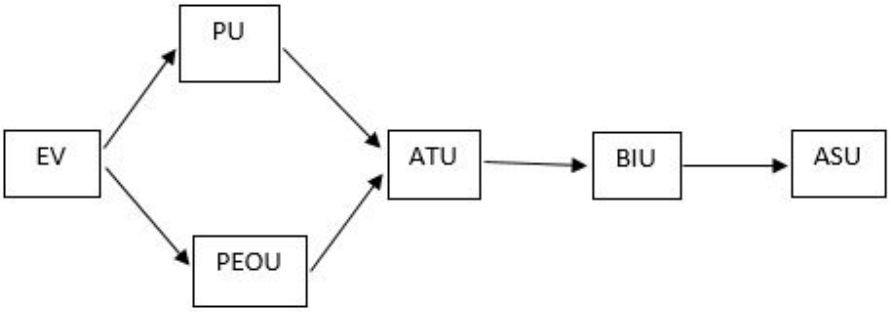

Figure 3. 4: TAM model
(Source: Davis, 1989)

Technology Acceptance Model

The TAM was adopted as a conceptual framework to guide the formulation of the lesson observations, interview questions and focus group discussion. The aim of using these instruments was to obtain a better understanding of SQ1, SQ2 and SQ3. In order to successfully implement paperless classroom in mathematics teaching and learning, there must be positive attitudes, beliefs and behavioural intentions. The attitudes of teachers towards technology were important for initial acceptance. Learners enjoy using e-books because they are easy to use and this also predicts behavioural intentions to use technology.

Table 3. 7: Link between instruments and TAM

(Source: The researcher, 2017)

Instruments	EV	PU	PEOU	ATU	BIU	ASU
Lesson observations		3,4	1,2,5	7	8	6
Semi-structured interviews	1,2,3,9,11	10	3	12,13,14		
Focus group	9	1,2	3,5	2	4,6	7,8

The TAM influences the research question on how the research should be investigated. This is done by creating a link between the determinant of TAM and the data collection instruments as illustrated in Table 3.7 above. The table shows how each determinant of TAM is linked to each instrument. The instruments were used to determine the strength and direction of the relationships among the variables. They were also used to investigate the degree to which participants believed that using a particular system would improve their performance and would be free of effort.

3.6. DATA ANALYSIS

Data analysis is defined as a process that seeks to condense, categorise and give sense to collected data (Thorne, 2000). Qualitative data analysis involves classifying, changing and modelling data with the aim of identifying out useful data and forming a conclusion (Cohen et al., 2011). It is the process that is used by individuals to clearly understand the phenomenon that is being investigated. In addition, it describes what an individual has learnt with a little interpretation (Thorne, 2000). It simply describes the method that the researcher has followed to analyse data. Data were broken-up and separated into manageable units, to enable the researcher to sort and select them according to their types and patterns. Patterns of expressions which arose from the data were presented in the participants' own words. Qualitative data was arranged in the form of visual images, voice recordings and field notes. Finally, data were summarised in order for meaning to be identified (see Chapter 4).

3.7. CATEGORISING

Categorising is the process in which objects and ideas are grouped into categories for a specific purpose (McMillan & Schumacher, 2013). It is the process of allocating a label to phrases, sentences or paragraphs that have meaning. It is an essential part of qualitative data analysis that eventually determines the themes that will be generated. Categorising was used as a strategy to analyse data and identify facts of the research study (Clarke & Braun, 2017). It was used as a way of categorising data. Categorising was made in a different format, such as the abbreviation of key words and numbers in this study, as illustrated in Table 3.9 below. The researcher transcribed and analysed recorded data as follows:

- The response of each participant was organised separately and was later compared with the participants' data.
- Collected data were labelled and participants' responses were grouped into categories.
- Letters and numbers were used for categorisation to allow for easy interpretation. TA refers to teacher A in school A whereas TB stands for teacher B in school B. CA refers to learners in focus group school A and CB is learners in focus group school B.

The most important thing was to ensure that all the necessary and relevant data has been captured during the categorisation process. This was done by reviewing the data alongside the labels to ensure that all the information was captured.

Table 3. 8: Categorisation of the participants

Category	Description
TA	Refers to teacher A in school A
TB	Refers to teacher B in school B
CA (1, 2, 3…)	Learners in school A
CB (1, 2, 3…)	Learners in school B

Each instrument's results were summarised in tables (Table 4.1 – 4.7). After each instrument, the results were linked to the concepts in the TAM, as well as to the research question. All these results were summarized in Table 5.1. This table therefore links the results of the research questions to the results of the TAM.

3.8. TRUSTWORTHINESS

There are methods that are used to establish trustworthiness in qualitative research. These methods are credibility, transferability, dependability and confirmability (Anney, 2014). On the other hand, quantitative research uses internal validity, reliability and objectivity to establish trustworthiness. Therefore, trustworthiness refers to the establishment of the following four concepts which are explained in detail below.

3.8.1. Credibility

Credibility refers to how confident the researcher is in establishing that the findings of the research are reliable (Anney, 2014). This method is used by the researcher to establish the reliability by examining accuracy of the research data, data analysis and findings. These procedures can be used by the researcher to increase credibility in qualitative studies:

3.8.1.1. Prolonged engagement is the activity the researcher uses to learn the traditions and customs of the participants. This means being present in the natural setting long enough to build trust with the participants. It is important for the researcher to spend quality time at the site and examine any distortions and misinterpretation of the researcher's questions.

3.8.1.2. Member checking is used by the researcher to review the data, analyse categories, interpretations and conclusions with the participants. The participants were asked to read the transcripts of the discussions in which they participated. The purpose was to check whether the words matched what they said.

3.8.1.3. Persistent observation is used to look in detail at what the researcher examines and investigates.

3.8.2. Transferability

Transferability is another method used by a qualitative researcher to establish correctness of the research. This concept is used to relate the research findings of one situation with another similar setting to arrive at generalisability. The method provides an in-depth account of the

research site, respondents and instruments used to collect data to enable another researcher to evaluate whether applying the findings of one research can be generalised.
In contrast to transferability, a quantitative researcher uses external validity to establish trustworthiness.

3.8.3. Dependability

Dependability is a concept used by the researcher to assess the results and interpretation of the research to ensure they are supported by the data collected from the participants (Cohen et al., 2011). A qualitative researcher explains in-depth the exact methods of data collection, analysis and interpretation to ensure that another researcher should be able to follow the personal notes used by the researcher. Qualitative research cannot be transferred to another setting unless it is credible and it cannot be credible if it is not dependable.

In qualitative research, dependability is used to establish trustworthiness, whereas in quantitative research reliability is used to examine the consistency of measuring instruments that are used in the research. The researcher also uses the test-retest instrument to confirm reliability by using one measure for one group of participants, wait for a certain period of time, and then use the same instrument for the same group.

3.8.4. Confirmability

Confirmability refers to the extent to which the results are the product of the centre of the investigation and not of the investigator's prejudices. It is employed by qualitative researchers to establish trustworthiness of the study. Confirmability includes an audit trail with raw data that should be reviewed, for example, electronic records, written notes and documents. This method can be used to enable another investigator to confirm that the research is reliable when presented with the same data. Confirmability is attained when the results of a research speaks for itself, and are not based on the prejudices and assumptions of the researcher.

3.8.5. Hermeneutics principles

The hermeneutics principles were used to support the trustworthiness of data and analysis. Hermeneutics is a philosophical approach that helps researchers understand human behaviour and provides the philosophical grounding for interpretivism (Klein & Myers, 1999). It also provides the meaning and interpretation in historical text. It suggests methods that help to understand written data and are also concerned with the meaning of an institution which the investigator comes to know through verbal or transcribed data (Myers, 1997). Thomas (2010) claims that all human understanding is realised by repetition between considering the interdependent meaning of sections and a holistic view.

Klein and Myers (1999) recommended a set of principles founded on the hermeneutic orientation in order to enhance the quality of research. The hermeneutics principles show how the researcher moved from the small parts of the phenomena to the general view of the phenomena. This enabled the interpretation of text that led to a better understanding of the phenomena. The table below illustrates the different principles which form part of the hermeneutics circle in the specific manner in which it was applied.

Table 3. 9: Summary of hermeneutics principles and application (Source: Klein and Myers, 1999)

PRINCIPLE	DESCRIPTION BY KLEIN AND MYERS	APPLICATION OF THE PRINCIPLE
1 - The hermeneutic circle	This is the foundational principle and it guides the application of the other principles. It suggests that human understanding is realised by allowing for the interdependent meaning of units and their interrelationship.	The aim of the research was to investigate paperless classroom experiences in teaching and learning of Grade 7 mathematics. The primary research question was answered through engagement between the researcher and the respondents. The study was also guided by the conceptual framework.

2 - Contextualisation	This principle requires that the topic under investigation be put in its natural setting so that the intended participants can see how the implementation of paperless classrooms emerge.	The researcher saw participants as producers and not just as products of history. The researcher also understood that schools, people and technology are not fixed or static but constantly changing.
3 - The interaction between the researcher and the participants	There must be critical reflection on how the data is socially created through the relationship between the researcher and respondents. Social interaction between the researcher and participants is important as facts are produced when the relationship grows.	Data were collected as part of the engagement between the researcher and the respondents. The researcher recognised that the participants can be seen as interpreters and analysts.
4 - Generalisation	Requires relating the individual details revealed when interpreting data. This theory suggests that humans and non-humans are connected into actor-networks.	The researcher realised that the validity of the inferences collected from the case does not rely on the representativeness of participants in a numerical sense, but on the rationale used in describing the findings from the participants.
5 - Dialogical reasoning	Needs to be sensitive to potential discrepancies between the theoretical presumptions that guide the design and results. If the researcher realises that his/her findings are not aligned with his/her preconceptions, he/she will have to modify or abandon them.	The researcher recognised that pre-judgement is the starting point of understanding and engaged with the phenomenon to establish meaning.
6 - Numerous interpretations	Needs to be sensitive to potential differences in interpretations among the participants.	There were conflicting interpretations among the participants themselves about the usage of tablets.
7 - Suspicion	Needs to be sensitive to prejudices and systematic misrepresentations in the data collected from the participants.	The data acknowledged that some participants have prejudices towards the research questions.

3.9. LIMITATIONS

The results of this research will apply only to the schools which have participated in the study. This research is limited to paperless pilot schools in one of the districts in Gauteng province. It is also limited to two primary schools that are piloting the implementation of smart boards and tablets for teaching and learning. Many primary schools have not yet started integrating ICT for teaching and learning. Data has been collected from Grade 7 mathematics teachers and their learners. Due to time constraints, only one interview and focus group session in each school have been conducted.

Another limitation to this study was the time and cooperation it took to conduct the focus group interviews after school. Learners do not feel safe to stay longer after school because of recent incidences of child kidnapping and human trafficking. Teachers are given many extra duties to perform outside the classroom and after school hours. They attend workshops, phase, subject and cluster meetings which makes it difficult to find appropriate time to conduct interviews. The department has introduced many programmes that took away teachers' time. Teachers are required to do support programmes for learners who are struggling and in danger or at risk of repeating the grade. The teacher-participants agreed to give up their lunch time so that the interview could be conducted and completed.

3.10. ETHICAL CONSIDERATION

Research ethics are the values that differentiate between right and wrong behaviour (McMillan & Schumacher, 2010). The responsibility of the researcher is to protect the rights and values of the respondents (Cresswell, 2014). The purpose of establishing ethical codes is to serve as a procedure for good investigation to ensure that respondents in the research are not harmed. The researcher should be cautious of the ethical issues before, during and after the research. The ethical issues include informed consent, privacy, confidentiality, anonymity, honesty and trust.

In this study, the researcher took responsibility to ensure that all respondents were fully aware of the aim of the research. Participants were asked to sign consent and assent forms which clearly stated that participation was voluntary. The researcher explained to the participants that they could withdraw from the study anytime (see attached appendices D and F). They were assured of confidentiality and that their identity would not be revealed. The teacher-participants helped the researcher to explain the assent forms before the learners could sign. The researcher used the codes to replace the participants' names. The researcher told the participants that he followed the ethics codes of the University of Pretoria and any participant who felt that his or her rights had been violated could lodge a complaint with the university ethics committee.

3.10.1. University's Ethics Committee

The researcher applied for ethics clearance at the University's Ethics Committee (Appendix B attached) and a clearance certificate has been granted. It is required that participants and data collection instruments be made known and available respectively. All copies of letters of consent and assent must also be given to each participant and submitted to the ethics committee. The letters explain clearly the research process to each participant, what their role will be and the conditions regarding their anonymity.

3.10.2. Gauteng Department of Education

The researcher applied for approval to conduct research at the two primary schools in Gauteng province. The two primary schools were part of the pilot project that introduced paperless classrooms. The GDE granted permission to proceed with the study. One of their specifications included in the study was that data could only be collected during specific school terms. Data collection instruments were also submitted (Appendices G – I attached).

3.10.3. Informed consent

Informed consent is defined as ethics in research requiring that participants must be made fully aware of their role in any research study (Bryman & Allen, 2011). The informed consent is important for the appropriate behaviour of conducting research. The following are the ethical principles for informed consent:

- Respondents should be made fully aware about the purpose of the research.
- They need to know and understand their roles in the research.
- They must understand that they give consent voluntarily.
- The researcher must inform the participants that they may withdraw at any time.

In this study, the researcher took responsibility to ensure that all the respondents were fully aware of the aim of the research. The researcher obtained informed consent from the principal, mathematics teachers and learners in writing in the format as reflected in Appendices C to F). Respondents were informed about the aim, nature of the research and data collection methods that would be used prior to commencement. They were asked to sign consent and assent forms which clearly stated that participation was voluntary. The researcher explained to the participants that they could withdraw from the study anytime. Participants were assured of confidentiality and that their identity would not be revealed. The teacher-participants helped the researcher to explain the assent forms before the learners could sign. The researcher used the codes to replace the participants' names. The researcher told the participants that he followed the ethics codes of the University of Pretoria and any participant who felt that his or her rights had been violated could lodge a complaint with the university ethics committee.

3.10.4. Privacy

The researcher considered three principles of privacy in research which include; sensitivity of the data provided, the site being investigated and dissemination of data (Cohen et al., 2007). Privacy is an important aspect of ethical research practices in social research (Cohen et al., 2011). The researcher ensured participants that privacy would be maintained throughout the study. Fictitious names were used to replace participants’ real names to protect their identity.

Participants were given assurance that their identity would not be revealed to the public. Any identifying characteristics would be removed before dissemination of the data. However, since the aim of the research was to inform policy and decisions, the data provided may be used by the DoE to inform developmental strategies.

3.10.5. Confidentiality

Confidentiality refers to the manner in which research data of the participants is handled and disseminated (Corti, Day & Backhouse, 2000). Participants were assured that any information that they provided during the study would remain confidential. In addition, they were informed that their identities would not be revealed. Instead, fictitious names were used to replace their real names.

3.10.6. Honesty and trust

The researcher has adhered to the ethical principles about honesty and trustworthiness to collect data. He has built trust with the respondents in order to obtain credible data. The relationship was built from the first day when the researcher met the participants.

3.11. CONCLUSION

The methodology used in this study was multiple case studies with qualitative method to explore the experiences of teachers and learners in Grade 7 mathematics in township schools to inform further rollout of paperless classrooms. This chapter presented the description on how the selections of the research site and participants were made. The methods used to collect data were identified and discussed. The steps for ensuring trustworthiness were also explained as well as the researcher`s role in ensuring confidentiality and anonymity.

CHAPTER 4: RESULTS

4.1. INTRODUCTION

The chapter provides a descriptive layout of the results at the two primary schools in Gauteng province that are currently piloting the implementation of smart boards and tablets for teaching and learning in Grade 7 mathematics. Data were collected through lesson observations, interviews and focus groups as explained in Chapter 3, paragraph 3.4 and illustrated in Table 3.5. The researcher is required to search for patterns of generalisation across numerous sources.

There are three steps that need to be employed in order to analyse and interpret data, namely; categorising, interpreting and making proclamation. Categorising is the process in which ideas and objects are grouped into categories for a particular reason. The researcher attempted to group patterns observed in the data into meaningful categories.

Figure 4.1 below illustrates steps that could be followed to analyse and interpret qualitative data.

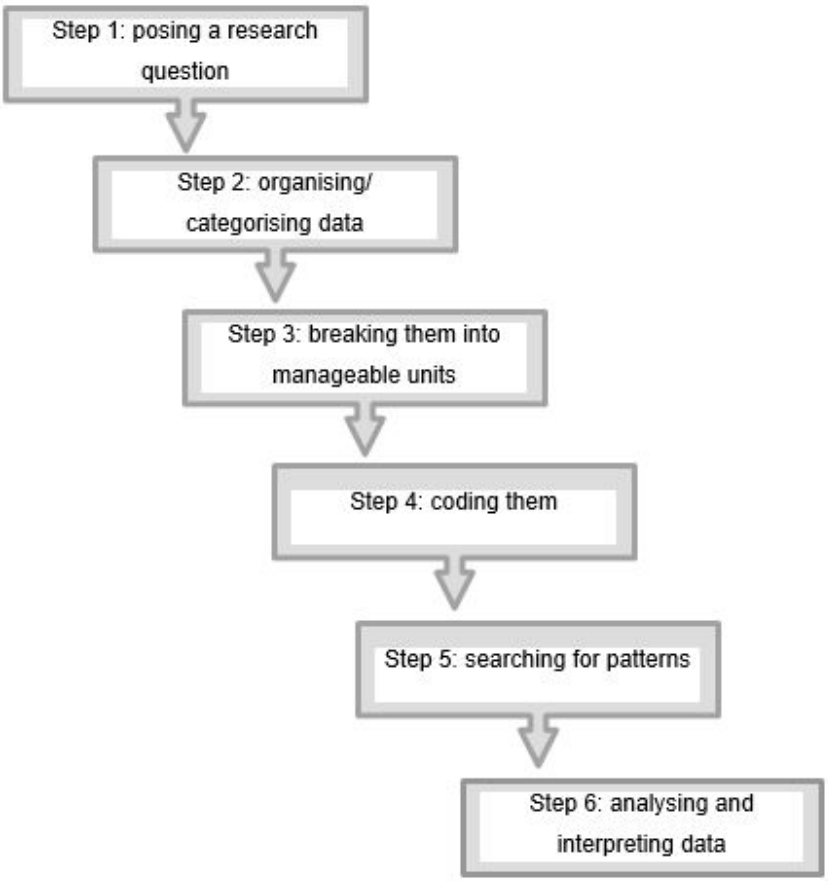

Figure 4. 1: Steps used in qualitative data analysis
(Source: The researcher, 2018)

4.2. STEPS FOLLOWED IN DATA ANALYSIS PROCESS

Data analysis requires steps to work through the raw data and create categories to reach the meaning that is included in the data. It is used to find patterns, concepts, themes and meanings. Data that has been collected was divided into categories to display similarities and dissimilarities to easily identify patterns in the study. The role of the researcher is to reduce data collected through all research methods and construct it into a meaningful whole. The process of analysing data started with categorising and organising data, looking for patterns and meanings. The researcher used labels to identify and cautiously label the categories.

In this study, interviews from both teacher-participants and focus groups were recorded and transcribed. During this process, valuable information that is closely linked to their experiences were analysed, compared, categorised and interpreted to arrive at the conclusion. Table 3.7 in Chapter 3 has been used to create a link between the instruments and the conceptual framework during the presentation of the results. The researcher collected data and wrote the report on the results, once all the measures to analyse the data have been followed.

4.3. RESEARCH PROBLEM AND QUESTION

The aim of the study was to learn about the rollout of paperless classroom in teaching and learning of Grade 7 mathematics in township schools. The reason behind the research is to answer the following question:

RQ. How can the experiences of teachers and learners in Grade 7 mathematics in township schools inform further rollout of paperless classrooms?

In order to enrich the content in understanding paperless classroom, the following secondary questions were formed.

SQ 1. How do teachers use smart boards and tablets in Grade 7 mathematics classrooms?

SQ 2. What are the problems confronted by teachers and learners when using the technology in teaching and learning of mathematics?

SQ 3. What are the positive experiences acknowledged by both teachers and learners when using technology in teaching and learning?

Categorising was used as a strategy to analyse data and identify facts of the research study. This concept refers to the process in which ideas and objects are documented, separated and understood (Cresswell, 2011). These objects are grouped into categories for a particular purpose. The researcher attempts to group patterns observed in the data into meaningful categories. He connects sections of themes in the data that are similar. Categorising helped the researcher to identify patterns and activities that are of interest and meaningful in order to organise the data sets (Saldana, 2013).

4.4. DISCUSSION OF THE RESULTS

The research aimed to investigate the employment of paperless classroom in teaching and learning of mathematics Grade 7 in two primary schools. Discussion of the results with learners and teachers was also audio recorded and added to the original data.

Technology acceptance research dates back to long ago (about two decades) with varying results and different supporting technology acceptance models (Venkatesh, Morris, Davis, & Davis, 2003). Results produced by some of the research are consistent with what the original authors claimed or suggested, while some oppose their recommendations. This research sought to provide understanding of issues surrounding acceptance of technology by teachers and learners using TAM.

4.4.1. Discussion of Observation results

Observation was used to collect data as one of the data collection method as explained in Chapter 3 paragraph 3.4.3.1. The researcher observed two lessons from each school to discover the implementation of smart boards and tablets in teaching and learning of Grade 7 mathematics. The researcher collected and recorded data in the following manner:

- The researcher sat at the back of the classroom throughout the lesson presentation, recorded the presentation, and took notes and pictures.
- The researcher observed the teachers' practices and application of smart boards in real life teaching and learning situations (see attached Figure 4.1, 4.2 and 4.3).

The main purpose of the lesson observation was to answer SQ 1, how do teachers use the smart boards and tablets in teaching and learning during mathematics lessons. Data were collected using the observation sheet (refer to Appendix G). The observation focused on the following criteria outlined below:

Case A

Connection and set up of the smart board

The teacher powered on the projector screen until a noise occurred. She pushed the power button on the projector. She used the special pen and touched the targets to control the board.

Basic functions/operations usage or ability to use functions on the toolbar

The teacher pressed the smart board icon in the windows notification area at the bottom left of the screen and the smart board tools menu appeared: selected start > programmes > smart board tools as shown in Figure 4.2. The smart board is operated by clicking each tool with a special pen or sometimes a finger. The teacher used the lesson plans already installed in the smart board. At first she struggled with the volume and while she was waiting for the technical assistant, she managed to troubleshoot the problem.

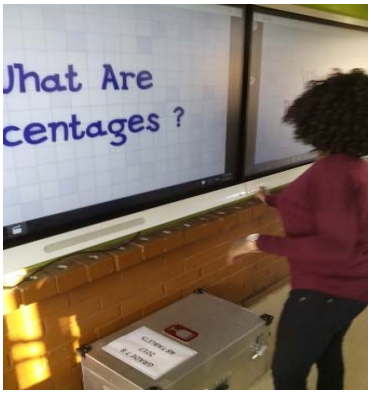

Figure 4. 2: Basic functions

(Source: The researcher, 2017)

Teach a lesson that demonstrate appropriate level

There are e-Lessons with YouTube videos uploaded in the smart board by the service provider appointed by GDE ICT unit. Learners watch the video and the teacher will from time to time pause the video to emphasise certain aspect of the lesson and ask questions to find out if they understand. They watched the video on “percentage”, which was their topic.

Ability to fix basic troubleshooting

The teacher managed to troubleshoot the volume. There was no further fault that required troubleshooting.

Management of tablets during teaching and learning

Learners are not allowed to switch on the tablets when the teacher is presenting the lesson. They were only asked to switch them on when they were writing the activity. They do not write on the tablets. Their tablets do have e-books which they use to refer and copy the activity into their classwork books. Some learners' tablets did not have mathematics e-books and they were asked to share with those who do have it. The teacher asked learners who did not have e-books to raise their hands so that she can take their names down and report the matter to the Intern Technical Assistant who will then forward the report to the service provider.

Teacher knowledge and confidence

The teacher showed more confidence than the ability to use the smart board as shown in Figure 4.3. The technical difficulty (for example, challenge with volume) that arose during the lesson did not affect her confidence. Learners showed more interest in learning and fully participated in the lesson. The teacher was also able to show learners some video clips to help explain the concepts.

Figure 4. 3: Lesson presentation
(Source: The researcher, 2017)

Case B

Connection and set up of the smart board

The teacher did not connect the laptop to a smart board. It was already on when she walked into the classroom. Figure 4.4 (picture A) shows where the server for the Wi-Fi is stored and how it is connected, whereas picture B shows the aerial for the Wi-Fi mounted on the wall. The cell phone tower does not form part of the investigation.

A

B

Figure 4. 4: WI-FI connection in Case B
(Source: The researcher, 2017)

Basic functions/operations, usage or ability to use functions on the toolbar

The smart board is used as a touchpad and writing surface. The teacher uses an electronic pen to write on the smart board. To delete the information, there is an eraser. The teacher tapped on the SMART Notebook which gives access to a number of tools. She looked confident using the toolbar and on-screen keyboard. She can effectively use the gallery to search for videos with a relevant lesson plan.

Teach a lesson that demonstrates appropriate level

The teacher started by playing a video on fractions. She stopped it and asked the learners what they have learned from the video. Learners gave various relevant answers to demonstrate their understanding and concentration.

Figure 4. 5: Lesson presentation on smart board

(Source: The researcher, 2017)

Ability to fix basic troubleshooting

Figure 4.5 shows the teacher performing basic operations. There was no fault from the smart board that required any troubleshooting except for the tablets that needed major attention which was beyond the teacher's control.

Management of tablets during teaching and learning

There were several learners that did not receive tablets because they were not charged**.** Tablets were received by a few learners and they were not enough for sharing. Some of the tablets were freezing and some did not have e-books. The number of learners with working tablets was 14, the tablets that were faulty were nine, the number of learners with tablets that were not charged were 17, seven learners never received tablets at all and the total number of learners in the class was 47. The teacher had to collect the tablets back and send them back to the storage room.

Teacher knowledge and confidence

The smart board was already on when the teacher walked into the classroom. She looked confident using the toolbar and on-screen keyboard. She effectively used the gallery to search for videos with relevant lesson plans. So, the attitude of the teacher was positive and that confirmed to the researcher that she effectively implemented technology in the daily mathematics' lesson.

Lesson observation result summary

Here follows a discussion of the observation results as linked to the conceptual framework (TAM). The result summary demonstrates the application of TAM to measure the participants' use of technology. It summarises the findings regarding the positive and negative experiences observed. Following the above-mentioned lesson observations, the researcher noticed that teachers in case A and B were able to power on and connect the smart board. They used a special pen to write on the smart board and they were able to troubleshoot minor challenges such as volume and internet connectivity. In both case A and B only a few learners' tablets were working. Some were not charged, whereas some were freezing and some did not have e-books. In case A, learners were able to share and work together and in case B only 14 tablets out of 47 were working as explained in the results of the lesson observation. Learners were asked to use textbooks

External variables

Positive experience – The smart boards in both schools are installed with e-books. The GDE also installed free high speed Wi-Fi. The functionality of tablets could stimulate learners' interest and help them to achieve the learning outcome. The GDE has appointed Interns at each school to assist with minor technical problems and the distribution and collection of tablets.

Negative experience – the non-functionality of technology devices could create challenges for both teachers and learners as they cause delay in completing the work and at times learners must share a few tablets that are working. There were some tablets which were not working at both schools and learners had to share.

Perceived usefulness

Positive experience

Both teachers were able to use the functions on the toolbar.

Negative experience

Tablets are only used to watch relevant videos on YouTube and have e-books. There are no applications to write activities.

Perceived ease of use

Positive experience

The teacher was able to show learners some video clips to help explain the concepts. Lesson plans are saved on the smart boards.

Negative experience

Some of the tablets were freezing and some did not have e-books and as a result learners could not use them.

Attitude toward use

Positive experience

Learners gave various relevant answers to demonstrate their understanding and concentration.

Negative experience

There was no specific negative experience observed.

Behavioural intention to use

Positive experience

The use of technologies in the classroom seems to have increased learners' interest and enjoyability in learning. Learners showed more interest in learning and fully participated in the lesson.

Negative experience

Learners whose tablets were not functional felt disappointed because they could not use their own tablets.

Actual system use

Positive experience

The smart board is used as a touchpad and writing surface. Learners' tablets do have e-books which they use to refer and copy the activities into their work books. In school B, the teacher can effectively use the gallery to search for videos with relevant lesson plans. Both teachers showed basic knowledge and skills in using the smart board.

Negative experience

There were several learners that did not receive tablets because they were not charged.

4.4.2. Discussion of Interview results

This paragraph explains the results of collected data from mathematics teachers at both primary schools. Teacher-participants' responses were outlined in a format that shows descriptions, categories and coding assigned to each participant.
Categorisation enabled the researcher to condense, categorise and organise meaningful data. In addition, it connected different sections of data that have common properties.
The researcher interacted with two teachers from two primary schools respectively. They were both asked the same set of questions and avoided long explanations. The interviewer conducted the interviews with the interviewees separately to avoid the possibility of sharing same answers.

4.4.2.1. Categorising the responses of semi-structured interview

The following Tables 4.1, 4.2 and 4.3 present the responses of teacher-participants transcribed from interview questions in Appendix I. TA is a teacher A in school A whereas TB refers to teacher B in school B. Comments are responses provided by teachers from both schools. The questions are later linked to the TAM as outlined below the tables.
Subsequent to the coding of the participants' transcribed comments in relation to the research questions and interview questions, the following categories in the tables were identified from the semi-structured interviews conducted with the mathematics teachers.

Table 4. 1: Technologies, experience using smart board, technology acceptance, problems and learners' attitude.

Category	Comment	Code
Q3 Availability of technologies	There are teachers' laptops provided by the department. Each Grade 7 learner is also provided with a tablet. Classrooms are fitted with smart boards and overhead projectors The school has smart boards, triumph boards, tablets, overhead projectors, laptops and desktop computers.	TA TB
Q4 Teaching fractions	It is *convenient* to teach fractions, as there are videos which help learners understand better. These technologies are very useful in engaging learners with new topics and lessons. Learners are *excited* as there are various lesson plans on YouTube and they have installed lesson plans on the smart board as well.	TA TB
Q5 Technology acceptance	Colleagues are positive about the use of technology as they are able to look for YouTube videos for similar lessons that they are teaching. They can scan any activity and display it on the smart board instead of using the textbook all the time. There are still teachers who are *resistan*t, especially those who are *near retirement*. Some say technology does not accommodate their teaching style. Some complain about *learners' performance* that it is dropping. There are some who are excited that it makes their *work easier* as there are various apps that can be used.	TA TB
Q6 Problems with the technology	Learners *download explicit videos, pictures and games* instead of focusing on school work. Even if we block them, but the way they are so *skilled* with technology they simply by-pass the codes and still access their games. When there is no electricity, *Wi-Fi* is also off. Learners are tempted by more fun than learning, as they download games and music. They even bring memory sticks to school so that they can put games and music. These are the distraction	TA TB

	when teaching. E-Books are deleted because of this games and the tablets also freeze and stop working.	
Q7 The attitude of learners using the technology	They are *excited* as the teacher is not only the person they listen to in class. There are also lessons on YouTube that help to support and enhance their understanding. Some are more *interested* in receiving the tablets in the morning so that they can play. There are some who see the need to use tablets for learning. The tablets have *improved* learner attendance.	TA TB

Table 4. 2: Support, internet connectivity, use of tablets and training

(Source: The researcher, 2017)

Category	Comment	Code
Q8 The nature of support given to learners	They are highly skilled. They are able to move around and do wonders without any help. Learners are *motivated* to use tablets effectively to improve their performance.	TA TB
Q9 Internet connectivity	The department installed a very strong Wi-Fi which covers the whole school. It sometimes does not connect on the tablets and we have to use textbooks. The school has Wi-Fi which is fast. When it is off the ICT coordinator calls the service provider who is appointed by the department and they quickly come to fix it.	TA TB
Q10 Use of tablets	E-Books are installed on the tablets and learners use them to copy down activities. They also use them to search for information, e.g. researching different careers, cultures, music and dance for Life Orientation. All nine e-books are uploaded on the tablet. The tablets are installed with the same apps that are on the smart board. E-Information is *easily accessible* and learners use it to complete activities in their workbooks. Learners can	TA TB

	document their field trips right away, e.g. going to the zoo. They can also make use of interactive maps.	
Q11 Training	Matthew Goniwe School of Leadership has been assigned to provide t*raining* on behalf of the department. They do send a trainer/officials at school to provide on-site *support* and conduct trainings in the afternoons. Yes, sometimes. Although Matthew Goniwe is supposed to provide training, their official is hardly at school. He always sends apologies and gives excuses that he is conducting other trainings.	TA TB

Table 4. 3: Problems with smart boards or tablets

(Source: The researcher, 2017)

Category	Comment	Code
Q12 Non-functionality of smart boards and tablets	If other learners' tablets stop working, they share, work together. The department has employed intern *technicians* who are stationed at school to provide technical support. They are trained to troubleshoot the smart boards when they freeze or malfunction. Sometimes smart board keeps on rebooting or restarting which is a challenge that teachers and school-based technicians could not resolve.	TA TB
Q13 Duration of fixing	Smart boards are not quickly fixed. The department has employed Intern technicians that are stationed at school and provide minor *technical support*. Tablets are never fixed. Just this year many learners' tablets did not have e-books and the problem was never solved. The same with the ones that are freezing and broken. Learners end up sharing few tablets.	TA TB
Q14 Barriers for using technology	Lack of departmental support and the school is a no fee paying school. There is no budget allocated specifically to ICT. The school relies on the department for various assistance and many times they delay to respond.	TA

	Tablets that are not working and never get fixed. There is insufficient training. Lack of *knowledge* of specific technology, e.g. saving to a home drive. Some teachers may not attempt to use technology related activities with their learners if they have not first learned basic skills.	TB

Interview results summary

Here follows a discussion of the interview results as linked to the conceptual framework, TAM. The findings revealed that both case A and B are well *resourced* (as explained in Table 4.1 – availability of technologies), but there are still problems that hinder effective integration of technology in the classroom (Table 4.1 – technology acceptance, TB indicated that there are still teachers who are resistant (especially those who are near retirement). There is a lack of knowledge of specific technology with various apps. Teachers must be encouraged to overcome their fear of change (Bitner & Bitner, 2002). TA stated that her colleagues are positive about the use of technology as they are able to look for YouTube videos for similar lessons that they are teaching. Teachers in both schools have received training and on-site support from the service provider appointed by the GDE. This was explained in Table 4.2 – The service provider has been assigned by the GDE to provide training on how to prepare lesson plans on the smart board. TA and TB both indicated concerns of teaching with technology in Table 4.1, that learners download explicit videos, pictures and games instead of focusing on school work. TB further stated that e-Books are deleted because of these games and the tablets also freeze and stop working. Learners are highly skilled in the usage of tablets as they are able to by-pass the codes that are used to block games as shown by TA in Table 4.1. Both schools have good internet connectivity (Wi-*Fi)* and learners use it to search for information in their tablets. Information is easily accessible and learners use it to complete activities in their workbooks. It is also indicated that the department has employed intern technicians that are stationed at school and provide technical support in both schools. The interns are trained to troubleshoot the smart boards when they freeze or malfunction. TA mentioned that the main barrier for using technology for teaching and learning was lack of departmental support and the school is a no fee paying school. There is no budget allocated specifically to ICT. Teachers are faced with problems in the implementation of technology-based pedagogy (Saud, Shu`aibu, Yahaya, &

Yasin, 2011). Teachers also complain about learner performance which is dropping. However, they mentioned that the tablets have improved learner attendance.

External variables

There are several external variables as listed in Table 2.2. There are factors which influenced the negative and positive behaviour of teachers and learners; such as: technophobia, training and motivation.

Technophobia

Negative experience

Teacher B indicated that senior teachers are afraid of making mistakes in front of learners. They need to be encouraged to overcome their fear of change.

Positive experience

There are some teachers who are positive about the use of technology as they are able to search for YouTube videos with similar lessons that they are teaching. Learners have knowledge using various apps on the smart boards and tablets.

Resistance

Negative experience

There are also teachers who are resistant, especially those who are near retirement. They say that when they make mistakes, learners will laugh at them. They perceive a smart board as a complicated technology device with unfamiliar applications. They claim that it will take them too long to adapt and master the new technology as it has many confusing applications.

Training

Positive experience

Teacher-participants acknowledge that they attended the training sessions and they found it useful. TA confirmed that the service provider does send their trainers to provide on-site support and training. Training enabled them to know how to use the smart board to improve their teaching. Some teachers are highly motivated to use technology. Both schools have high speed Wi-Fi which is reliable. Teachers are provided with laptops and learners with tablets. The

department has employed intern technicians who are stationed at school to help fix minor technical support problems.

Negative experience

Teachers at both schools admitted that the training that they received was very basic, as such they had to learn how to use some of the applications. There is insufficient training. Although they both commended training, but they felt that it was not enough. TB alleged that although the service provider sends the trainers, in most cases the trainers will send apologies. GDE does not provide enough support in terms of duration of fixing the tablets. Internet sometimes does not connect on the tablets. Some e-books are deleted and take long to be reinstalled.

Skills

Learners are highly skilled on the usage of tablets as they are able to by-pass the codes that are used to block games.

Perceived usefulness

Positive experience

Teachers alleged that technology made it easier to keep record of different files that they created during the lesson planning. Some teachers claim that the implementation of technology will improve their work by using lesson plans on YouTube and supporting the capturing of marks. Learners can document their field trips right away, e.g. going to the zoo. They can also make use of interactive maps.

Perceived Ease of Use

Positive experience

All participants found smart boards and tablets easy to use. They indicated that the names of the features on both technology devices were the same as the ones on their cell phones. All nine e-books are installed on the smart boards and tablets and they are user friendly. Teachers are provided with technology resources such as laptops, and learners with tablets. They can easily search for information and download information.

Attitude towards Usage

Positive experience

TA explained that learners are excited as the teacher is not the only person to listen to in the class. There are lessons on YouTube that help to support and enhance their understanding. The use of tablets has also improved learner attendance. Technology arouses learners' interest in learning. The technologies are very useful in engaging learners to new topics and lessons.

Negative experience

TB as concerned that learners download explicit videos, pictures and games instead of focusing on school work. She also revealed that learners were tempted more by fun than learning as they downloaded games and music. She further explained that learners brought memory sticks to school so that they could save games and music. She was concerned that these games and music disrupt teaching and learning. Some learners were more interested in receiving the tablets in the morning so that they can play.

Motivation

Positive experience

There are some teachers who feel motivated because with the use of technology they can store all their information on the laptop. They do not have to carry around textbooks from one class to the other.

Behavioural intention

Positive experience

Teachers indicated that they intended using technology devices for their teaching practice.

Actual system use

Positive experience

Learners were excited as there were various lesson plans on YouTube and they have installed lesson plans on the Smart board as well. E-Books are installed on the tablets and learners use them to copy down activities. Learners also use them to search for information. E.g. researching different careers, cultures, music and dance for Life Orientation. Teachers can scan any activity and display it on the smart board instead of using the textbook all the time

Negative experience

There was a decrease in learner performance. Learners download explicit videos, pictures and games instead of focusing on school work.

4.4.3. Discussion of Focus Group results

Focus groups were conducted in the two primary schools as part of the data collection method. The purpose of this focus group was discussed in Chapter 3 paragraph 3.5.3.4. The target group is also outlined in Table 3.3. The researcher used focus group interviews to find more information. Focus group interviews help participants to exchange ideas among themselves. Participants feel relaxed in sharing their experiences and ideas in group activity.

Categorising focus group interviews

Focus group discussions are outlined in a table format below that shows descriptions, categories, and comments assigned to each focus group. CA stands for **Case A** (focus group in school A) and CB refers to **Case B** (focus group in school B) and numbers represent different learners who participated in that school. Responses were transcribed according to the research questions and interview questions in (Appendix I).

Case A

Table 4. 4: The use of tablets, feelings about tablet use, problems, reaction and duration of fixing

(Source: The researcher, 2017)

Category	Comment	Code
Q1 Tablet as learning tool	For example, if we do not understand we can check in our textbooks and we can look for more examples to help you understand.	CA 1
	If our math teacher is using another teaching method, we can use an example of method that we understand better.	CA 2
	To get more information about what the teacher is talking about.	CA 3
Q2 Feelings about tablet use	We feel bad because tablets do not have textbooks and the school does not have hardcopies of textbooks	CA 4
Q3 Problems with tablets	We use it as if we are using our phones.	CA 5
	Other learners are playing games, they do not concentrate.	CA 6
Q4 Reactions on tablets not working	We use the smart board, because they have the same apps as the tablets.	CA 1
	We ask for the textbooks.	CA 3
	Our teacher can use the laptop to display the work.	CA 1
	I raise up my hand and ask the teacher to share with the person I am sitting with.	CA 5
	I ask our teacher to write on the whiteboard.	CA 7
Q5 Duration to fixing	It does not take a day because there are extra tablets in the computer lab. They replace the tablet with a new one.	CA 8
	No, they don`t get fixed because there are extra tablets.	CA 2
	Some do not have textbooks.	CA 4

Table 4. 5: Additional problems, assessments, training and performance

(Source: The researcher, 2017)

Category	Comment	Code
Q6 Additional problems	A few of us do not have e-books.	CA 8
	If the tablets are not working we tell the ICT Coordinator to reload the e-books.	CA 2
	E-Books are deleted.	CA 3
	The teacher asks us to Google and realised that they do not have internet access.	CA 4
	We do not have password for the Wi-Fi.	CA 2
Q7 Writing of assessments on the tablet	Yes, there is this app called the SOCRATIVE students and we write answers in the tablets.	CA 6
	Our mathematics teacher logs in.	CA 8
	We have two different types of tablets, Samsung and Huawei.	
	On Samsung we have passwords to log in and use them like textbooks.	CA 5
		CA 3
Q8 Training	We just learned by ourselves.	CA 8
	If we have new learners in the class and is not comfortable using the tablets, we teach them.	CA 2
	ICT coordinator tells us what to do up until we know how to use them.	CA 6
	If a new learner does not know we call our ICT coordinator.	CA 4
Q9 Performance	No, we come with our cell phones and send the games to our phones.	CA 8
	We do not concentrate because we download pornography, games and music.	CA 4
	It is only minority.	CA 8
	When they give us tablets, some learners use them like their cell phones.	CA 7
	Learners insert USB in the smart board, when she writes the work is deleted.	CA 2

	We also prepare magic pen beforehand, so that when the teacher is writing the work disappears. We do not receive them on Fridays, because the school comes out early.	CA 8 CA 7

Case B

Table 4. 6: The use of tablets, feelings about tablets, problems, reactions and duration of fixing

(Source: The researcher, 2017)

Category	Comment	Code
Q1 Tablet as a learning tool	If we don't understand the lesson, we can be able to research and so that we can know more about what we are learning and see examples of what we are learning. If we don't understand the lesson we use the e-books that have all the information we need in the tablets. There are YouTube videos that we use to get the correct answers.	CB 1 CB 2 CB 3
Q2 Feelings about tablet use	We feel excited because they help us understand the lesson easily. Sometimes we feel bad because our tablets freezes or the e-books do not open.	CB 4 CB 5
Q3 Problems with tablet use	They sometimes download happy games by themselves and funny videos. Sometimes the tablet do not have e-books inside, so we use textbooks.	CB 2 CB 4
Q4 Reactions on tablets not working	If the tablets are not working we use our textbooks, sometimes if the tablets are not working, our teacher uses the smart board so that we can understand the lesson easily.	CB 1
Q5 Duration of fixing	They never get fixed. Follow up question: Do you report the matter? Learners all said No! Yes!	CB 6 CB

	Follow up: You keep quiet if they not working? We don't know where to report. Follow up: You don't tell the teacher? We do tell the teacher. Follow up: You tell the teacher. Yes, Sir Follow up: But they never get fixed. Sometimes we sit without tablets.	 CB 1 CB 1 CB CB 4

Table 4. 7: Additional problems, assessments, training and performance

(Source: The researcher, 2017)

Category	Comment	Code
Q6 Additional problems	The problems that we experience is that sometimes when we switch them on, they just switch themselves off even if the battery is full. The tablet sometimes installs games and photos by itself. Follow up: What kind of games? Happy games They just download themselves. Nothing else.	 CB 5 CB 7 CB 7 CB 7 CB 8
Q7 Writing of assessments	No Sir. We write them in our workbooks, but sometimes our teacher gives us assignments to do them in our workbooks. We only write in the workbooks We cannot submit answers but we can send to someone else	CB CB 8 CB 8 CB 1
Q8 Training	No We learned by ourselves because they have same features as our cell phones.	CB 3 CB 8
Q9 Performance	We cannot say our performance has been improving because the use of tablets, we never get them because our teacher	CB 5

	punishes us because of downloading games or doing some bad things with our tablets. Follow up: So that means if you are naughty they punish you by not giving you tablets. Yes Follow up: Can you say you are using tablets in the classroom? No Sometimes	 CB CB CB 8

Focus group results summary

Here follows a discussion of the focus group results as linked to the conceptual framework (TAM).

Based on the above-mentioned discussions, it was discovered that some problems arise from maintenance of tablets. In case B in Table 4.6, learners mentioned that broken tablets never get fixed. This shows that both the district and GDE do not provide enough support in terms of technology integration. In Table 4.6, learners again alleged that tablets freeze and e-books are deleted. These problems were reported and never received attention as cited by learners in Table 4.6 – Q5.

Learners enjoy working with technology, although they need to be guided and supervised so that they do not use it for the wrong purpose. Learners were using the tablets for non-subject related purposes. This was confirmed in Table 4.7 – Q9, when learners revealed that the teacher sometimes punished them by not handing them out if they downloaded games and pictures. It is very clear that in case B learners were not fully using tablets for learning as was mentioned in their discussion.

External variables

Positive experience

School A has extra sets of tablets provided by another service provider. The ICT coordinator provided training in school A. He reinstalled e-books that were deleted.

Negative experience

There was no training provided in school B. If there is no electricity, Wi-Fi is also off. There is poor maintenance of tablets. There is no duration set for fixing tablets with problems. The GDE and district do not provide enough support.

Perceived usefulness

Positive experience

Learners used the tablet to search for more information. They improved their performance.

Negative experience

Learners are playing games, they do not concentrate. Problems that were reported never received timeous attention.

Perceived ease of use

Positive experience

The teacher in school A uses a laptop to display the work on the smart board. Learners enjoy working with technology.

Negative experience

Learners share tablets because some are either not charged or are broken.

Attitude toward use

Positive experience

Learners are excited because tablets help them understand the lesson better. Learners enjoy working with technology, although they need to be guided and supervised so that they do not use it for the wrong purpose.

Negative experience

They feel disappointed when the tablets are not working.

Behavioural intention to use

Positive experience

Learners feel excited to use the tablets.

Negative experience

They download music and games.

Actual system use

Positive experience

Learners have access to learning materials that are from various sources and continually updated.

Negative experience

Learners were using the tablets for non-subject related purposes. They did not concentrate because they downloaded games and music.

4.5. FINDINGS

The section provides a brief summary of results and is based on the discussions in Chapter 4 paragraphs 4.4. The findings are presented in more detail in the TAM discussion in Section 5.3 and in Table 5.1. The research instruments that were used to collect data were lesson observations, semi-structured and focus group interviews in (Appendices G – I). This research aimed to investigate paperless classroom experiences in teaching and learning of Grade 7 mathematics in township schools. Learners have access to learning materials that are from various sources and continually updated. Teachers acknowledge that the implementation of ICT has reduced the amount of paperwork and workload as most of the things are done electronically, e.g. files and lesson plans that can be re-used.

While teachers acknowledge that there are positive changes brought by the implementation of technology, some issues remain unresolved. The results of this research show that ICT is not fully implemented in teaching and learning especially in case B. Learners are not given the tablets because e-Books are deleted, they download games, music and explicit materials. Teachers need to develop strategies and find a solution to curb the problem. A significant shortcoming is that the deployment of ICT into schools has not been as successful as the department had intended. Teachers who feel uncomfortable using the smart board, still prefer to use the normal chalkboard. They do not have any plans of implementing technology in their classrooms.

All teachers need to be persuaded to support the implementation of ICT in the classroom. They need to develop confidence in using ICT in the classroom. The teachers should continue to receive in-service training on the use of smart boards. It is also mentioned by both schools that they do not receive the necessary support from the district and GDE in trying to resolve the challenges. These challenges are reported, but no action is taken to resolve them. E-Books are in PDF format (read only) and are only used like textbooks.

4.6. CONCLUSION

This chapter discussed analysis and interpretation of results in the study. The analysis was discussed under data collection instruments; lesson observations, interviews and focus group discussions. The results showed that there were problems that delayed the implementation of technology in teaching and learning. It was mentioned in both schools that although training was provided, it was not enough to address the teachers' challenges. The department was also not doing enough to support the schools with dysfunctional tablets and smart boards. There were also positive experiences that were highlighted about the rollout of technology. The next chapter discusses the findings and conclusion of the research, including the recommendations that derived from the study.

CHAPTER 5: FINDINGS AND CONCLUSIONS

5.1. INTRODUCTION

This study was conducted to investigate paperless classroom experiences in teaching and learning of Grade 7 mathematics in township schools. From the analysis and discussion, the study has found the external variables that influence technology acceptance model and are illustrated in Table 5.1. This chapter summarises the research questions, presents the findings, limitations, practical contribution and reflection of this study. It also makes suggestions for further research and provides some ending comments.

5.2. OVERVIEW OF THE RESEARCH

- **Chapter One** provides a summary of the research and addresses the introduction, background, research focus, methodology, data collection, population and sampling, limitations and ethical considerations.
- **Chapter Two** links the relevant literature study and gives a general overview of mathematics teaching and learning, the South African education environment, the South African implementation of ICT in education, the South African policy on ICT, Paperless classroom, International implementation of ICT in education and the theoretical framework.
- **Chapter Three** describe the methodology, time horizon, participants, data collection process, conceptual framework, data analysis, categorising, trustworthiness, limitations and ethical considerations.
- **Chapter Four** discusses data analysis process, research problem and questions, discussion of results, findings and conclusion.
- **Chapter Five** provides for summary of the research questions, presents findings, proposes practical implications and identifies limitations, suggestions of further research and conclusions.

5.3. REVISIT THE CONCEPTUAL FRAMEWORK: TAM

Technology Acceptance Model (TAM) was used by Davis (1989) to investigate computer usage behaviour. His aim was to describe the general determinants of technology acceptance that lead to explaining user's behaviour across a wide variety of end-user computing technologies. The basic TAM model comprised and tested two predictors of use, namely; Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Perceived Usefulness is defined as potential user's subjective possibility that the use of a particular system will improve an action. Perceived Ease of Use refers to the degree to which the potential use expects the target system to be effortless (Lai, 2017). The belief and confidence of an individual towards a system may be influenced by other factors referred to as external variables (see Table 2.2) in TAM.

The model also has a dependant variable known as a Behavioural Intention to Use (BIU) and is closely linked with actual behaviour. The intention to use a particular technology is largely determined by the PU of the technology to the person and the perception of ease of use that an individual may have (Hartmann et al., 2013). These two beliefs influence an individual's attitude towards using the technology. Attitude and usefulness influence an individual's positive or negative experience and behavioural intention to use a system. Attitude and usefulness are defined as the strength of the user's intention to use the system (Hartmann et al., 2013). Furthermore, intention predicts actual behaviour which is defined as an individual's frequency of a system's use. TAM has become broadly considered as the most usable model for predicting the acceptance of information technology (Lai, 2017).

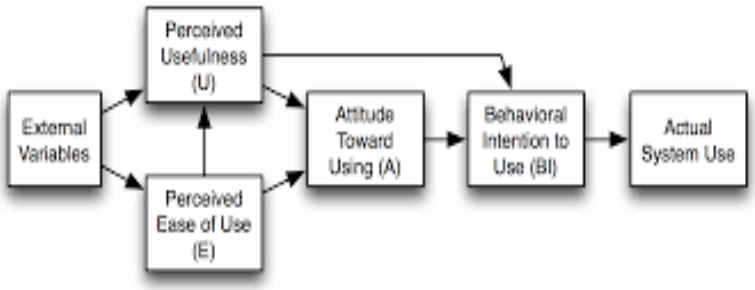

Figure 5. 1 TAM model

(Source: Davis, 1989)

Technology Acceptance Model

TAM has long been used to investigate the acceptance of new technologies. Davis (1989) proposed a TAM model that he thought would explain the effects of external variables on user acceptance of technologies. This model (Figure 5.1) demonstrates how users come to accept and use technology. The model proposes that when users are presented with technology, a number of factors influence their decision about how and when they will use it, namely; PU and PEOU and their attitudes towards the use of the technology. TAM also suggests that a user's acceptance of an information system is reliant on two elements which are PU and PEOU. These two elements determine attitude towards using the technology. This in turn influences the behavioural intention to use, which then leads to actual system use.

The link between TAM and research questions

Table 5.1 below illustrates the link between TAM variables and the research questions. This table summarises the results of the lesson observations, interviews and focus group discussions that were collected in Chapter 4. The process followed after each instrument and towards the final summative table in the last chapter, linking data to the conceptual framework. TAM seems to be an appropriate model for understanding conceptual issues of technology use. It proposes that the success of technology implementation can be determined by user acceptance, measured by external variables, perceived usefulness, perceived ease of use, attitude towards use, behavioural intention and actual system use. A number of external variables emerged during data collection using the research instruments. External variables influence perceived usefulness and perceived ease of use. The determinants of TAM were used to identify factors that influence the implementation of technology and were also linked to the research questions.

Table 5. 1 The link between TAM and the research questions

TAM ref	SQ1 Use	SQ2 Problems	SQ3 Positive	Instrument ref
EV	Access resources quickly, Wi-Fi is fast and reliable	Insufficient training and support, Technophobia, Lack of motivation, trainers do not pitch	Wi-Fi, ICT infrastructure provided, interns employed to assist with minor technical support	O – 3, 6 I – 3, 6, 9, 11, 12 F – 8
PU	Make teaching easier, convenient	Deletion of e-books, tablets never get fixed, downloaded games, some teachers complain about learner performance	Save documents, enhance quality of teaching and learning, Improves school attendance and performance	O - 4 I – 4, 5, 13, 14 F – 1, 9
PEOU	Learners find it easy to interact with tablets, some teachers find smart board difficult to use	Tablets freeze, not charged	All e-books are installed	O – 7 I – 5, 6, 14 F – 3,
ATU	Use videos to teach, Teaching and learning are convenient	Teachers' perceptions	Less paper, stimulate teaching and learning,	O – 7 I – 4, 7, 10, F – 2
BIU	Some teachers intend to use technologies in their teaching	Resistance, anti-social behaviour	Shows interest in learning	O – 7 I – 6, F -
ASU	Research information, watch videos	Tablets not working, cannot write activities in the tablets, use workbooks	Copy activities	O - I – 10 F – 4, 7, 1

O = Observations; I = Interviews; F = Focus Groups

This research confirms that there are several external variables that enhance or delay the implementation of technology based on the factors mentioned in Table 5.1. It was discussed in the literature study that there are a wide variety of choices which make it easier for learners and teachers to use technology (Hobgood & Ormsby, 2011). There are also non-technical factors that affect the adaptation of ICT in schools, for example a low level of ICT literacy and technophobia amongst the teachers (Department of Education, 2003). It was discovered that some teachers lacked self-confidence with the new technologies and were resistant to implement them to improve teaching and learning. The integration of ICT in schools requires teachers who are ICT trained, as ICT skills would give them confidence and make their use of technology in the classroom easier. However, the GDE's paperless classroom initiative provides teachers with laptops and learners with tablets so that they are able to access online education content. The classrooms are equipped with smart boards and internet connectivity.

The above table unpacked the factors that influence the use of technology by using the TAM model and linking them to the research questions.

- SQ1 was used to classify factors that make technology easier to use.
- SQ2 was used to classify the problems that hinder the implementation of technology.
- SQ3 was used to classify the positive experiences mentioned by both teachers and learners when implementing technology.
- The instruments were used to gather the data.

External variables influence the beliefs of the teachers and learners towards the use of technology (Table 5.1). They also influence PU, PEOU and BIU.

Perceived usefulness – this variable tries to determine how technology could contribute to teachers' and learners' use in the classroom to enhance teaching and learning. It makes it easier and convenient to search for information.

Perceived ease of use – Based on the above table, the implementation of technology could allow the user (teachers and learners) to work competently. Some teachers find it difficult to use technology.

Behavioural intention to use – PU and PEOU influence the user's intention to use technology. BI directly influences actual use of technology in teaching and learning.

5.4. RESEARCH QUESTIONS REVISITED

In this section the research findings are discussed per research question. This research was intended to find solutions to the research questions listed in Chapter 1 paragraph 1.3.2.

5.4.1. SQ 1: How do teachers use smart boards and tablets in Grade 7 mathematics classrooms?

It was evident in this study that technology has become an integral part of everyday life for most learners. Learners find tablets easy to use and are experienced in using technology for various tasks. It is convenient to teach, as there are even videos which help learners understand better. They reported that tablets were easier to carry and the Wi-Fi is fast and efficient. The tablets enabled better or easier learning as they are able to access resources quickly.

Teachers use YouTube videos on smart boards to simplify their teaching as indicated in Table 4.1. There is a gallery loaded with many pictures and videos that help explain the lesson. The researcher realised that the teachers sometimes use the smart board as substitute to traditional chalkboard. Teachers receive in-service training from Matthew Goniwe School of Leadership so that they are able to use and prepare lessons on the smart board. This training focused on capacitating teachers in the form of professional development to use interactive and multi-media content that are uploaded in the smart board.

5.4.2. SQ 2: What are the problems confronted by teachers and learners when using the technology in teaching and learning of mathematics?

The findings revealed major problems when technology is used in the classroom

- Technical support: Smart boards keep on rebooting or restarting which is a challenge that teachers and school-based technicians (interns) could not resolve. Teachers and learners also raised concerns that broken and freezing tablets never get fixed. Sometimes tablets do not charge even if they are put on chargers overnight. The main concern is the time it takes to resolve such technical problems. The department does

not always respond to all the problems that have been raised with them. Learners in case A create own passwords just to lock the smart board so that teachers may not be able to use the board. Teachers also mentioned in Table 4.1 that learners downloaded games, explicit pictures and videos. They also bring their own games in memory sticks to watch with their peers during unattended periods.

- Lack of departmental support: Although teachers are currently using smart boards for teaching and learning, GDE and the district do not coach or show them how to use smart boards to teach a specific subject.
- Deletion of e-Books: Learners accidentally delete e-Books applications or readers from the tablets.
- Technophobia: Some teachers are still struggling to embrace the initiative. There are teachers who are scared to use technology resources and claim to be too old to understand new technology software. This is technophobia and this was mentioned by TB in Table 4.1.
- Training: Teachers at both schools admitted that the training that they received was very basic, as such they had to learn how to use some of the applications.
- Resistance: There are still teachers who are resistant, especially those who are near retirement.
- Learners downloaded explicit videos, pictures and games instead of focusing on school work.

5.4.3. SQ 3: What are the positive experiences acknowledged by both teachers and learners when using the technology in teaching and learning?

ICT has the potential to bring about exciting curricula, based on real-world challenges into the classroom (Donnelly, 2005). The educators' attitude toward technology in the classroom is very important in order for successful integration (Albirini, 2006). It allows more opportunities for participation and increases lesson enjoyment and motivation. It is convenient to teach, as there are videos which help learners understand better. Learners are able to access lessons and relevant videos on YouTube. The department has provided each teacher with a laptop and learners with tablets and has also employed intern technicians who are stationed at school to

provide technical support. The use of tablets has improved learner attendance. The department also installed a very fast and reliable Wi-Fi network which covers the whole school. Learners do not have to carry a huge amount of books to school as e-Books are uploaded on the smart boards and tablets. Teachers also stated that there has been a reduced workload as prepared lessons could be used over and over again.

5.4.4. Main RQ: How can the experiences of teachers and learners in Grade 7 mathematics in township schools inform further rollout of paperless classrooms?

Generally, this study identified a variety of problems, positive and negative experiences that teachers and learners face in implementing smart boards and tablets in teaching and learning. Teacher-participants reported high levels of access to internet and laptops. They also mentioned that all learners are supposed to have tablets in the classroom, however this is not the case due to problems such as tablets freezing and some not being charged and e-books being deleted (see Table 4.1 –Q6). Based on the learners' responses to focus group discussion, it emerged that the tablets were used primarily as e-textbooks, for research information and to find educational videos on YouTube. A small number of learners admitted using tablets for social media. The other positive aspects are the learner attitudes toward the use of tablets as it reflected perceived enjoyability. They showed a distinctive pleasure and interest in using tablets in the classroom.

The results of this study have shown that much still needs to be done to successfully implement technology in the classroom. Some teachers have demonstrated resistance as they feel threatened by learners who are quick to learn the application of the new technology devices, whereas some have indicated that teaching and learning is now stimulating, as there are videos which help learners understand the lesson better. These technologies are very useful in engaging learners with new topics and lessons. Learners are excited as there are various lesson plans on YouTube and they have installed lesson plans on the smart board as well.

5.5. LIMITATIONS

The results of this research will apply to schools which formed part of the research. The research is limited to e-Learning schools in primary township schools in Gauteng. The two primary schools are piloting the implementation of smart boards and tablets for teaching and learning. Observation sessions – when teachers in both schools were demonstrating how they used tablets during teaching sessions, some learners could not use their devices due to other circumstantial factors. As a result, not all learners were able to use their tablets. However, there was still sufficient data collected for analysis. Although the researcher wished to include other schools, unfortunately other schools which are implementing the use of smart boards and tablets are secondary schools. Many primary schools have not yet started integrating ICT for teaching and learning. Data was only collected from Grade 7 mathematics teachers and their learners. Again, due to time constraints, only two interviews and two focus group sessions have been conducted.

Another limitation to this study is the time and cooperation it took to conduct the focus group interviews after school. Learners did not feel safe to stay longer after school because of recent incidences of child kidnapping and human trafficking. Teachers are given many extra duties to execute outside the classroom and after school hours. They attend workshops, phase, subject and cluster meetings which made it difficult to find an appropriate time for the interviews. Teachers are required to do support programmes for learners who are struggling and in danger or at risk of repeating the grade.

The use of one research method can limit the findings of the research. The researcher used qualitative method and this could be one of the reasons for some limitations in respect of addressing all areas that are related to the RQ. Data analysis has a representation of a small number of participants, therefore generalisation to a broader population could not be made.
These limitations could still contribute to provide assistance regarding the adoption of the results and suggested future research.

5.6. REFLECTION

The research drew on theoretical framework which is TAM developed by Davis (1989). TAM is claimed to be a well-known model and has proven to help to explain and predict use and behaviour of information technology (Park, 2009). The researcher gained valuable knowledge and experience through interaction with the participants while sharing their experiences, problems, attitudes and beliefs in the rollout of paperless classroom. The research process was one of trial and error. Having only little knowledge and experience of conducting research, it was always challenging to find methods to approach things. Starting off the research I did not know where to go, but working under my supervisor has given me the opportunity to develop good research skills.

Interpretivism was chosen as a philosophy to be able to determine how the participants constructed their meaning of the phenomena. The interpretivist paradigm was influenced by hermeneutics and phenomenology. The role of the researcher was to investigate, learn and understand the experiences of teachers and learners in Grade 7 mathematics in township schools to inform further rollout of paperless classrooms.

5.7. CONTRIBUTION: SUGGESTIONS FOR FURTHER ROLLOUT

The contribution of this research is in the information gathered from the two case studies. In order to effectively implement technology, schools need to be fully supported by the department with regard to training and on-site technical support. This will help to increase the level of technology implementation.

5.7.1. Training of teachers should be improved

Technology training is continually needed so that teachers are able to apply it correctly and confidently in the classroom. They must be thoroughly trained since they are responsible for implementation. Teachers will be motivated to change their negative perceptions about the use of technology in the classroom. ICT should be used as an effective instructional tool for teaching

and learning. It is reported in Table 4.2 that the official assigned to conduct training for teachers is hardly ever at school.

5.7.2. GDE support should be improved

GDE must monitor and fully support the implementation of ICT usage in the classroom. According to learners' responses in Table 4.5 and 4.6 challenges are not speedily resolved. The researcher suggests that more needs to be done to ensure that learners are aware of the usefulness of tablets and the benefits of using them. The researcher also observed that the use of tablets has the ability to enhance learning through curiosity and co-operation and can also make learning fun.

5.7.3. Guidelines on ICT and White paper on e-Learning

The guidelines must be updated to include the use of smart boards and tablets in teaching and learning. Teachers need a clear guideline so that they are able to implement technology more efficiently.

5.7.4. Provision of qualified technical assistants

The GDE allocated the schools with interns who are also still learning and lack the necessary skills to provide technical support (Table 4.3). GDE should provide schools with qualified technical assistants to help in the maintenance and fixing of technology devices. Lack of efficient technical support frustrates the teachers and this will result in them losing confidence in ICT. Teaching and learning should not be wasted as a result of teachers fixing or trouble-shooting smart boards and tablets. Technicians must be employed to assist with trouble-shooting, fixing technology resources and providing any form of technical support.

5.7.5. Changing teachers' perception about ICT

A teacher in Table 4.1 indicated in her response that technology does not accommodate their teaching style, especially those who are near retirement. Teachers should be persuaded and motivated to change their negative perceptions about the use of technology in the classroom. The schools must manage and change the way tablets are currently being used in the classroom. According to learners' responses, the main function of the tablets in mathematics teaching and learning was using them as e-books. There were no additional features such as educational applications and online learning.

5.7.6. Awareness of the idea of ICT implementation in schools

Stakeholders who are currently not involved in ICT issues should be made conscious of the role and benefits of ICT in schools. They must also be trained on how technology can be employed. Stakeholders such as SGB members must be updated and informed about the importance of ICT in schools. They should be encouraged to support and defend ICT initiatives at governance level.

5.8. PROPOSED FURTHER RESEARCH

Based on the findings of this qualitative research and literature discussed in Chapter 2, further research can be conducted in various areas to aim for more effective implementation of paperless classrooms. Further research should involve all teachers and district subject advisors to obtain their perceptions on technology integration. Such study should focus on the attitude of teachers and subject advisors towards the use of ICT in the classroom.

Since this study focused mainly on two primary schools that are piloting paperless classroom, further study should investigate what other schools are doing and how they are integrating technology in teaching and learning.

5.9. FINAL CONCLUSION

The research sought to answer how the experiences of teachers and learners in Grade 7 mathematics in township schools can inform further rollout of paperless classrooms. This chapter concludes this study in mathematics teaching and learning in paperless classroom and has found that successful ICT implementation in the classroom depends on the level of support that teachers receive from the GDE and district. The DoE suggested that the use of ICT in the classroom should be implemented by 2013, however, this initiative had challenges and was delayed. (Wilson & Thomson, 2005).

ICT provides learners with various ways to learn and make sense of their world. It can either be used in appropriate ways that are useful to learners or it can be misused. ICT must not be used to substitute teachers, but must be used to supplement teaching and learning materials. Learners must be allowed to use their tablets to enable them to improve their learning. Despite the limitations and shortcomings, this study provides valuable insights into learner attitudes towards technology and the challenges confronted by teachers and learners in the rollout of paperless classroom.

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Appendix A: Personal declaration of responsibility

Faculty of Education

Title of research: **Paperless classroom experiences in Grade 7 mathematics in township schools**

1. I declare that I am conscious about the goals of the Research Ethics Committee in the Faculty of Education to:
    - Develop among students and researchers a high standard of ethics and ethical practice in the conduct of educational research.
    - Cultivate an ethical consciousness among scholars especially in research involving human respondents.
    - Promote among researchers a respect for the human rights and dignity of human respondents in the research process.
2. I subscribe to the principles of:
    - Voluntary participation in research, implying that the participants might withdraw from the research at any time.
    - Informed consent, meaning that research participants must at all times be fully informed about the research process and purposes and must give consent to their participation in the research.
    - Safety in participation put differently that the human respondents should not be placed at risk or harm of any kind. E.g. research with young children.
    - Privacy, meaning that the confidentiality and anonymity of participants should be protected.
    - Trust, which implies that the participants will not be subjected to any acts of deception or betrayal in the research process or its published outcomes.
3. I understand what plagiarism entails and am aware of the University`s policy in this regard. I undertake not to make use of another person`s work without acknowledgement

or to submit it as my own. I also undertake not to allow anyone to copy my work with the intention of using it as his/her own work.

4. I understand that the data collected in the course of research become the property of the University of Pretoria and I undertake to transfer all raw data and documents related to research for safekeeping as required by the Faculty of Education.
5. I understand that any amendment to the approved protocol needs to be submitted to the Ethics Committee for review prior to data collection. Non-compliance implies that approval will be null and void.

KE Kganyago	_____	_____
Applicant	Signature	Date
Dr. R Callaghan	_____	_____
Supervisor	Signature	Date

Appendix B: GDE Ethical clearance certificate

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. M2017/241A

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	13 February 2017
Validity of Research Approval:	06 February 2017 - 29 September 2017
Name of Researcher:	Kganyago K.E
Address of Researcher:	47 Namakwaduif Street
	Birch Acres
	Kempton Park , 1618
Telephone Number:	011 972 8066 078 258 1362
Email address:	Kgabokganyago721@gmail.com
Research Topic:	Paperless classroom experiences in Grade 7 Mathematics in township schools in Ekurhuleni North District
Number and type of schools:	Two Primary Schools
District/s/HO	Ekurhuleni North

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the

17/02/2017

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix C: Permission to visit the school

Feb/March 2017

Faculty of Education

Letter of permission: The principal

Dear Sir/Madam

Title of research: Paperless classroom experiences in Grade 7 mathematics in township schools

A group of lecturers at the Faculty of Education at the University of Pretoria, in collaboration with other researchers, are investigating different aspects of the incorporation of mobile devices to promote innovation in teaching and learning. This part of the research focuses on Paperless classroom experiences in Grade 7 mathematics in township schools. We are investigating a diverse variety of environments, with the aim to identify what the state of Mobile Learning is in those environments. Your environment brings a unique view into this picture and it would therefore be appreciated if you can give permission for a few of your staff members and/or students to participate.

Participation in this research will be through **lesson observations, interviews and focus groups** of your mobile teaching and learning practices. Our interest is in the uptake of the mobile technology, processes implemented, and the impact on teaching practice and /or studies.

Participation in this study is voluntary, confidential and anonymous. Participants will be free to withdraw participation and unprocessed data previously supplied at any time without any explanation or prejudice.

"*All data collected with public funding may be made available in an open repository for public and scientific use*."

Should you agree to this participation, please read the following and sign the letter of consent:

- I consent to the participation in investigations into the mobile teaching / learning practice in our environment.
- I authorise the researchers to use the information gathered.

We look forward to learning with you!

Dr Ronel Callaghan for the e-Learning Group

PERMISSION FOR RESEARCH
I, _____, hereby give my consent for my school to participate in the study. I am assured of anonymity, and know that I can withdraw anytime if I do not wish to participate any more. Signature: _____ Date: _____ Researcher: KE Kganyago Date: February 2017

Appendix D: Letter of consent to the teachers

Feb/March 2017

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Letter of permission: Teacher-participant

Dear Sir/Madam

Paperless classroom experiences in Grade 7 mathematics in township schools.

A group of lecturers at the Faculty of Education at the University of Pretoria, in collaboration with other researchers, are investigating different aspects of the incorporation of electronic (mobile) devices (laptops, tablets, smartphone, etc.) to promote innovation in teaching and learning. We request that you participate in this research where we shall explore challenges, developments, implementations and impact of mobile education in the South African context. This part of the research focuses on Paperless classroom experiences in Grade 7 mathematics in township schools. We are investigating a diverse variety of environments, with the aim to identify what the state of Mobile Learning is in those environments.

We would like to involve you in this research through lesson observations and interviews of your technology teaching and learning practices. Our interest is in the uptake of the technology, processes implemented, and the impact on your teaching practice and /or studies.

We request that, if you are interested to participate, you firstly complete the questionnaire that will be handed out. The questionnaire will take about 30 – 40 minutes to complete, depending on how much detail you provide. Your participation in the questionnaire will be seen as consent.

"*All data collected with public funding may be made available in an open repository for public and scientific use*."

Secondly, if you would like to be involved in further discussions and lesson observations of your practice, please contact kgabokganyago721@gmail.com

Should you agree to participate, please read the following:

- I consent to participate in the investigations into the mobile teaching / learning practice in my own environment.
- I authorise the researchers to use the information gathered.
- I acknowledge that:
    - I have been informed that participation is voluntary and I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied.
    - I have been informed that the confidentiality of the information I provide will be safeguarded.
    - I will be referred to by pseudonym or code name in any publications arising from the research.

We look forward to learning with you!

Ronel Callaghan for the e-Learning Group

PERMISSION FOR RESEARCH (should you agree to further discussions and observations)

I, _____, hereby give/ do not give my consent to participate in the study. I am assured of anonymity, and know that I can withdraw anytime if I do not wish to participate any more.

Signature: _____ Date: _____

Researcher: KE Kganyago Date: February 2017

Appendix E: Letter of consent to the parents

Faculty of Education

Feb/March 2017

Letter of permission: Parent/ guardian

Dear Sir/Madam

Title of research: Paperless classroom experiences in Grade 7 mathematics in township schools.

A group of lecturers at the Faculty of Education at the University of Pretoria, in collaboration with other researchers, are investigating different aspects of the incorporation of electronic (mobile) devices (laptops, tablets, smartphone, etc.) to promote innovation in teaching and learning. We request that you participate in this research where we shall explore challenges, developments, implementations and impact of mobile education in the South African context. This part of the research focuses on Paperless classroom experiences in Grade 7 mathematics in township schools. We are investigating a diverse variety of environments, with the aim to identify what the state of Mobile Learning is in those environments.

We would like to involve your children in this research through lesson observations, interviews and focus groups of technology teaching and learning practices. Our interest is in the uptake of the technology, processes implemented, and the impact on teaching practice.
"*All data collected with public funding may be made available in an open repository for public and scientific use*."

We request that if you give consent for your child to participate, you complete the attached form.

Secondly, if you would like further clarity about the research, please contact kgabokganyago721@gmail.com

Should you agree to give consent for your child to participate, please read the following:

- I give consent for my child to participate in the investigations into the mobile teaching / learning practice.
- I acknowledge that:
    - I have been informed that participation is voluntary and participants are free to withdraw from the project at any time without explanation or prejudice.
    - I have been informed that the confidentiality of the information provided will be safeguarded.
    - Participants will be referred to by pseudonym or code name in any publications arising from the research.

We look forward to learning with you!

Ronel Callaghan for the e-Learning Group

PERMISSION FOR RESEARCH (should you agree to further discussions and observations)

I, _____, hereby give/ do not give consent for child to participate in the study. I am assured of anonymity, and know that my child can withdraw anytime if he/she does not wish to participate any more.

Signature: _____ Date: _____

Researcher: KE Kganyago _____ Date: ____February 2017

Appendix F: Letter of assent to the learners

Faculty of Education

Feb/March 2017

Letter of permission: Learner-participant

Dear Learner

Paperless classroom experiences in Grade 7 mathematics in township schools.

A group of lecturers at the Faculty of Education at the University of Pretoria, in collaboration with other researchers are investigating different aspects of the implementation of technology (mobile devices) such as laptops, tablets, smartphone, etc.) in order to improve teaching and learning. We request that you participate in this research where we shall discover challenges, developments, implementations and impact of mobile education in the South African context. We are conducting research study about Paperless classroom experiences in Grade 7 mathematics in township schools. A research study is a way to learn more about people.

If you decide that you want to be part of the study, you will be involved through observation (in the classroom) and focus group discussions (after school) of your technology teaching and learning practices.

When we are finished with this research study, we will write a report about what was learned. This report will not include your name that you were in the study. We would still take good care of you no matter what you decide. We would also make sure that no bad things happen to you during the research.

You do not have to be in the study if you choose not to do so. If you decide to stop after we have started, no one will be upset. If you say yes, you can always say no later. You will also be allowed to ask questions if you do not understand.

"*All data collected with public funding may be made available in an open repository for public and scientific use*."

Should you agree to participate, please read the following:

- I have been informed that participation is voluntary and I am free to withdraw from the study at any time without explanation.
- I have been informed that the confidentiality of the information I provide will be safeguarded.
- I will be referred to by pseudonym or code name in any publications arising from the research.

We look forward to learning with you!

Ronel Callaghan for the e-Learning Group

PERMISSION FOR RESEARCH (should you agree to further discussions and observations)

I, _____, hereby do/ do not accept to participate in the research study. I am assured of anonymity, confidentiality and know that I can withdraw anytime if I wish not to participate any more. I will not be forced to take part in the study.

Signature: _____ Date: _____

Researcher: KE Kganyago Date: February 2017

Appendix G: Lesson observation sheet

1. Connection and set up.

_____

2. Basic functions/operations usage.

_____

3. Ability to use functions on the toolbar.

_____

4. Use of drop box to store and share lessons.

_____

5. Teach a lesson that demonstrate appropriate level.

_____

6. Ability to perform basic troubleshooting.

_____

7. Teacher’s knowledge and confidence.

_____

8. Management of tablets during teaching and learning.

_____

_____

Appendix H: Semi-structured interview questions

1. Number of years of teaching experience. _____
2. Number of years teaching Grade 7 mathematics. _____
3. Which technologies are available to teachers for use?

_____

4. Describe your experiences teaching fractions with the use of smart board.

_____

5. How do you observe the technology acceptance of your colleagues?

_____

6. What are your concerns of teaching with technology?

_____

7. How does the implementation of technology in your class change the attitude of the learners?

_____

8. What is the nature of support that you provide to learners with regard to the use of technology?

_____

9. How is the school's internet connectivity?

_____

10. How are the tablets being used for teaching and learning?

_____

11. Do you receive training on how to prepare lesson plans on the smart board?

_____

12. What happens when the smart board or learner's tablets stop working?

_____

13. If tablets or smart boards are broken, how long does it take for them to be fixed?

_____

14. What in your opinion, are the barriers in the use of technology for learning?

_____

Appendix I: Focus group interview

1. How did the use of tablet as a learning tool help you understand the lesson?

_____

2. How do you feel about using a tablet in the classroom?

_____

3. Are you experiencing any problems with the tablets?

_____

4. What do you do when tablets are not working?

_____

5. How long does it take for your tablets to be fixed when they are broken?

_____

6. What are the problems you experience with the tablets? (Except when they are broken)

_____

7. Do you write assessments on the tablets? (If not where do you write them)

_____

8. Have you ever received training on how to use a tablet?

_____

9. Do you think your performance has improved or dropped since the use of tablets in teaching and learning of mathematics?

_____