AN EXPLORATION OF THE INTEGRATION OF TECHNOLOGY BY MATHEMATICS TEACHERS: THE CASE OF 10 SCHOOLS IN KWAZULU-NATAL UNDER UMLAZI DISTRICT

Masters Dissertation

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Keywords

Integration

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Abstract

This interpretive qualitative study sought to explore the integration of technology by mathematics teachers in Umlazi district of KwaZulu-Natal province. A purposive non-probability sample of ten teachers from ten different schools in Umlazi district participated in the study. Data was collected from the participants using a questionnaire, interview, classroom observation schedule and document analysis, while the thematic analysis method was employed to analyse the data.

The findings of the study revealed that the South African Department of Basic Education advocates for the integration of technological tools for all teaching and learning processes in basic education. However, the study showed that teachers underutilise the technological resources they have at their disposal and that they mainly rely on the teaching of mathematics using traditional methods of teaching.

The findings established possible factors contributing to the underutilisation of technology by mathematics teachers in Umlazi district. These factors include: (1) lack of training to confidently integrate technology; (2) lack of technology pedagogical content knowledge; (3) limited access to technological tools; (4) crime (break-ins); (5) overcrowded classrooms; (6) lack of technical support for software updates; (7) electric power failure during the teaching and learning hours; and (8) lack of exposure to government policies advocating for technology integration in teaching.

Lastly, the study found that though teachers are not actively utilising the technological tools in the teaching of mathematics, they however demonstrated a positive attitude towards its use. The results further showed that if the factors above are well addressed, the mathematics teachers in Umlazi district would be utilising their tools effectively in their teaching practices.

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List of Abbreviations

CAPS – Curriculum and Assessment Policy Statement

DBE – Department of Basic Education

DoE – Department of Education

ICT – Information and Communication Technology

TAM – Technology Acceptance Model

TPCK/TPACK – Technological Pedagogical Content Knowledge

TATP – Tech Age Teacher Project

TRA – Theory of Reasoned Action

TPB – Theory of Planned Behaviour

AED – Academy for Educational Development

FET – Further Education and Training

ATPs- Annual Teaching Plans

NECT – National Education Collaboration Trust

TPD – Teacher Professional Development

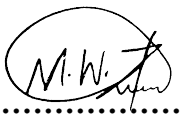
HSSREC – Humanities and Social Sciences Research Ethics Committee

Declaration

I, **Mzwandile Wiseman Zulu,** declare that:

An exploration of the integration of technology by mathematics teachers: The Case of 10 Schools in KwaZulu-Natal under Umlazi District

…is my work and has not yet been submitted for award requirements at this or any other institution of higher education. The thesis contains, to the best of my knowledge, no material previously published or documented by another person except where reasonable reference has been made.



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Professor Vimolan Mudaly **Date**

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Chapter 1: Introduction

1.1 INTRODUCTION

The present chapter outlines the background, context, and the purpose of this research. The chapter further describes the scope and significance of the study and presents definitions of some terms employed in this study. Finally, the last section of this chapter presents an outline of the remaining chapters of the study.

1.2 BACKGROUND OF THE STUDY

In my experience as an undergraduate student, I was exposed to the integration of technological resources for the teaching and learning of certain topics in mathematics. During my teaching practice as a pre-service teacher, I taught computer applications technology (CAT) as well as mathematics to the same grade. With exposure to the teaching of these subjects to the same grade, I would sometimes teach my learners mathematics in a computer LAB wherein I would integrate technology in my teaching of mathematics. Thus, at that stage, I began to find technology in my own teaching experience of mathematics useful, though ineffectively, since I had no little or no training on it.

Furthermore, when I qualified as a teacher, I was fortunate to be placed in a public township high school where technological resources were available for teachers to use in the department of mathematics, science and technology. These technological resources were donated by a private company with the intention of improving the level of performance for learners in both science and mathematics in the schools in Umlazi district. Thus, I usually made use of the following technological tools: Smartboard; laptop with smart notebook software; Geometer's Sketchpad, GeoGebra; overhead projector and sound bar, in my teaching of certain content areas in mathematics. I found this sometimes demanding and challenging since I had to train myself on how to use these tools. However, I got used to them, but not as an expert. Then, a professional IT specialist was invited to offer training on the use of the Smartboard technology that had been donated. Unfortunately, the training did not illustrate how to integrate the technological resources into the teaching of mathematics lessons. It was just a simple orientation training on how to use the hardware and software they had

installed. Nonetheless, with the daily use of the tools I became more effective in using and integrating them in my teaching of mathematics.

Stols, et al. (2015) assert that while the debate regarding the integration of technology continues, many developing countries in Asia, Latin America and Africa are exploring the use of Information and Communication Technologies (ICT) in teaching and learning. This implies that the existing results that have emerged regarding the use of ICT tools by developed countries may not necessarily hold for the developing countries like South Africa, thus more research is still required. For instance, Jantjies and Joy (2016) conducted a study in township and rural schools in the North West and Gauteng provinces to explore the use of mobile technologies in the teaching and learning of mathematics. The results from their study indicated that many teachers who participated in their research could access different forms of technological resources including laptops. However, the study further revealed that most participants were not actively using the technological tools at their disposal to support teaching and learning. From their study, participants indicated that "cultural practice of teaching in high schools did not historically support technology use in schools" (p. 8). However, what was worth noting from their findings is that teachers often gave learners assessments that required them to make use of technology.

In another study conducted by Mashile (2016) in South Africa, it was established that the country is still at its infancy stage when it comes to the integration of technology when teaching in schools as only 26% of teachers possess basic technological skills. Similarly, Saal (2017) affirms that one of the major barriers that exist with most South African teachers is that of the lack of competence to utilize technology during instruction in the classroom.

In addition, Padayachee (2017) argues that the integration of technology in the classroom has often been seen as a remedy in resolving educational challenges in South Africa. Nevertheless, Padayachee further argues that technology integration in South Africa is severely limited by infrastructure, strategic, pedagogic and operational challenges. In addition to these challenges, Padayachee (2017) asserts that there is minimal knowledge about the practical enforcement of technology in the South African classroom context. Thus, it follows that more research is required in this area to add knowledge relevant to the South African context.

According to Chisango and Lesame (2017), the government of South Africa has implemented an ICT policy with the purpose of addressing issues of universal access and service while attempting to improve the standard of teaching and learning in schools located in previously disadvantaged places. Chisango and Lesame (2017) outlines that the ICT policy framework in South Africa is underpinned by several pieces of legislation which include: the Electronic Transactions Act of 2005, the Electronic Communications Act of 2005, and the Broadband Policy. Additionally, Meyer and Gent (2016, p. 1) contend that:

> While strategy and policy exist, the implementation is slow, and capacity is limited. Objectives are not clear, and a strategy that is integrated across the system is lacking. Access to technology is limited and unequal across provinces and quintiles. In the absence of clear, integrative provincial strategies, progress is fragmented and driven by solution providers.

With that being the case in South African basic education, there are other contextual issues that exist within the country which impact on the integration of technology in teaching and learning. Some of the factors that are prevalent in South Africa emanate from the educational background of teachers and the background of learners. In some cases, pre-service teachers who were exposed to the integration of technology in teaching during their training ended up finding themselves in schools with limited technological resources to use for teaching (Meyer & Gent, 2016) upon graduation.

However, the increase in demand for the integration of technology in teaching has raised concerns in the private sector to such an extent that some private companies have developed interest in giving back to the community in the form of donating the technological tools to needy schools. In South Africa, mathematics and science are subjects which are given high priority (Mapaire, 2016; McCarthy & Oliphant, 2013; Simkins, 2010), thus, most companies donate science laboratories and other technological tools for the teaching of these subjects (Isaacs, 2007). Therefore, when teaching mathematics, teachers in some schools including township schools in the country can utilize technology for the teaching of this subject. In fact, several township schools in Durban have had the privilege of being sponsored with technological tools for teaching and learning mathematics and science subjects (Draper, 2010). However, with such scant research that has been conducted in the township schools regarding

the use of technological tools by teachers, there is little knowledge that exists about how these are integrated in the context of township schools.

1.3 CONTEXT

The potential of the technological tools in improving the standard of teaching and learning has encouraged a number of private companies as well as the Department of Basic Education (DBE) in South Africa to gradually invest in education with these tools, especially for subjects like mathematics and science. Consequently, some schools in some districts in the country have been provided with these technological tools. In the province of KwaZulu-Natal, selected schools in and around the city of Durban have been provided with these tools, but minimal research has been conducted in this province to investigate the usage of these technological tools after reception.

1.4 PURPOSES

The primary purpose of this research is to explore teachers' integration of the technological tools that they have at their disposal to teach mathematics in Umlazi district schools. The Technology Acceptance Model (TAM) is utilized as a theoretical framework to explore and comprehend (a) the external factors that teachers encounter in the process of technology integration, (b) the perceived usefulness of technology in the classroom and (c) the perceived ease-of-use of technology which are the fundamental impact factors for their (d) attitude towards use and also (e) behavioural intentions.

Thus, the objectives of this study are to: (i) evaluate teachers' experiences towards the use of technological tools in the teaching of mathematics; (ii) establish the extent to which mathematics teachers integrate available technology into the teaching of mathematics; (iii) explore the challenges that teachers encounter when integrating technology in the teaching of mathematics and (iv) establish the contribution of technology in the teaching of mathematics from the teachers' experiences.

In achieving these objectives, this study is going to respond to the following main research questions:

- What are teachers' experiences on the use of technological tools in the teaching of mathematics?
- How do mathematics teachers integrate available technology into the teaching of mathematics?
- What are the challenges that mathematics teachers encounter in the process of implementing technology into their teaching and how do they deal with such challenges?
- How is technology contributing to the teaching of mathematics?

1.5 SIGNIFICANCE AND SCOPE

In the past two decades, the South African Department of Education [DoE], now renamed Department of Basic Education [DBE], has been promoting, encouraging and supporting the use of technological resources in teaching and learning. For instance, the DoE White Paper 2003 and 2004 and other policy documents thereafter have been advocating for the provision of educational technologies to teachers and learners (Wilson-Strydom, Thomson, & Hodgkison-Williams, 2005). In particular, teachers have been expected to equip learners with computer literacy and to integrate these technological tools in their teaching. Thus, in the process of this transformation, there has been a need for teacher professional development (TPD) (Meyer & Gent, 2016). This means that the department and other private stakeholders who provide technological tools for schools ought to provide some form of training for teachers who are expected to make use of these tools.

Thus, numerous researchers both locally and internationally have been conducting several studies regarding the issues pertinent to the use of technological tools in the process of teaching and learning. Mainly, research studies have been focusing on the teaching and learning of mathematics with the use technology as it is believed that technology has the potential to enhance the teaching and learning of this subject (Mthethwa, 2015; Drijvers, et al., 2016; Radović, Marić, & Passey, 2019). This

study is expected to contribute and shed light on comprehending the integration of technology in the teaching of mathematics.

A lot of research has been focusing on establishing the effectiveness of educational technologies in the teaching and learning of mathematics where some authors have been interested in exploring the learner performances when taught with and without these technologies. However, not much research has been conducted to comprehend the integration of technology by mathematics teachers when teaching in township schools in a South African context. Thus, this study has identified that issue as a research gap and hence attempts to add knowledge on the integration of educational tools by mathematics teachers when teaching.

This study was conducted in ten schools in Umlazi district of KwaZulu-Natal province in South Africa. All the ten schools where data were collected are located in the township area. The context of South African township schools is discussed in detail in the next chapter. From the literature, it seems there is little research on the integration of technology in the teaching of mathematics in this context. It would then appear to be reasonable at this point to conduct a study that would add on knowledge that is not currently common.

1.6 DEFINITION OF TERMS

It is important at this subsection of the chapter to understand that concepts and terms may have different meanings to different people depending on their context. Thus, a brief definition of key terms that were mainly utilised in this study is provided in this subsection.

Technology Integration – technology integration has been defined and understood to mean different things to different people depending on the context in which it is utilized. This study defines technology integration, from the teaching and learning perspective, to mean using digital tools such as computers, projectors, smartboard, tablets, speakers, and so on, efficiently and effectively in the process of teaching and learning (Dockstader, 1999, p. 74). Technology integration in the context of this study includes using both hardware and software to support teaching and learning.

Mathematics – Khan (2015) defines mathematics as “the study of some logical and philosophical notions” (p. 98). For the purpose and context of this study, the term mathematics is going to be defined according to the Curriculum and Assessment Policy

Statement (CAPS) as “a human activity that involves observing, representing and investigating patterns and qualitative relationships in physical and social phenomena and between mathematical objects themselves” (2011, p. 8).

Teacher – is someone who teaches or imparts a body of knowledge to those who are learning (Oxford Advanced Dictionary, 2010). In the context of this study, a teacher is defined as a qualified individual who has undergone professional training to gain skills of being able to mediate learning or to impart knowledge of a particular subject matter.

1.7 THESIS OUTLINE

This subsection of the study presents the outline of chapters in chronological order. A brief synopsis of each chapter is presented below.

Chapter one: Introduction and overview

This chapter provides the background and context of the study. It further presents the purpose, the research questions, significance of the study, the scope and delimitation of the study. Finally, a brief definition of terms relating to the context of this study is presented in this chapter.

Chapter two: Literature review

Chapter two of this study provides the review of literature that is relevant to the study.

Chapter three: Theoretical framework

This chapter provides details of the theoretical framework that underpins the study.

Chapter four: Research Design

This chapter describes the research methods, the research paradigm and approach. It further describes the research style, location of the study, the population

and sample of the population, data collection methods, trustworthiness and ethical issues pertaining to the study.

Chapter five: Data Presentation and Analysis

This chapter starts off by presenting the profiles of the ten participants in this study. Thereafter, it presents the findings and analyses them according to themes which respond to the main research questions of the study.

Chapter six: Discussion of results, conclusions, limitations and recommendation

This chapter discusses the results of the study, conclusions and limitations. Recommendations are made based on the findings.

Chapter 2: Literature Review and Theoretical Framework

2.1 LITERATURE REVIEW

2.1.1 Introduction

The purpose of this chapter is to discuss the literature review with the main focus on the specific aspects that relate to the teachers' use of technology in the teaching of mathematics. Moreover, the review of this literature will present issues that are related to learner's performance when they are taught mathematics using technological tools. Thus, the first section presents the definition of the term technology in relation to the purpose of this study. Thereafter, the context of South African urban and township schools is outlined. In addition, the purpose and impact of integrating technology into the teaching and learning of mathematics is discussed. Furthermore, this chapter examines in-service teacher knowledge on the usage of technological resources as well as the use of these resources at teacher training institutions. Moreover, the different models of technology integration are also discussed and finally the chapter scrutinises the availability of technological resources in South African schools.

Concerned by the performance of learners in mathematics, many researchers (Githua, Changeiywo, & Mwangi, 2018; Makhubele, Nkhoma, & Luneta, 2015; Mthethwa, 2015; Sinay & Nahornick, 2016; Stols et al., 2015) teachers and other stakeholders are in a quest to establish an antidote that can be utilized to improve learner performance. Khobo (2015) notes that both international and national researchers have had discourses on how the subject mathematics could best be taught to improve learner achievement, while making it a subject that is appealing to learners. Khobo (2015) therefore argues that the disappointing performance of South African learners in mathematics may be caused by the outdated teaching methods that teachers utilize. Also, Umugiraneza, Bansilal and North (2017) concur that in order to make mathematics teaching more effective, teachers should be concerned with the actual methods of teaching they employ to aid and simplify the learning of mathematics. The concern with regards to how teachers impart the knowledge of mathematics using the available resources in their disposal propelled the researcher to conduct this study with the focus on teacher's utilization of technology.

2.1.2 Defining technology

According to Ihde (1993), the etymological roots of the word technology stems from the ancient Greek word technologia which is the combination of two words (techne – "art, craft or skill" + ology – "study of"). Thus, "technology was considered to be the study of knowledge and skills involved in specialized arts (that is technologia)" (Isman, 2012, p. 210).

Carroll (2017) assert that technology is a complex concept to define, and different scholars have conceptualised it from different perspectives. From an anthropological perspective, people think of technology as human artifacts such as tools, electronic devices, machines, or scientific hardware (Carroll, 2017, p. 9). Isman (2012) extends it from an anthropological perspective and contends that human's views of technology should not only include machines (computer hardware) and tools. He therefore argues that "technology is more than a collection of machines and devices. To go beyond simplistic intuitions about technology requires investigation of the human mind and socio-cultural environment as well as interactions with technological artifacts" (p. 207).

In addition, Volti (2008) defined technology as comprising of the standards, forms, and classifications of the more prominent expressions, especially those which include applications of science.

Nevertheless, Ihde (1993), Feenberg (1991) and other theorists claim that there cannot be a single definition of the term technology as it means different things to different people depending on their context. Thus, it will be an unproductive exercise to search for an essential definition (Blackwell, 2006).

Blackwell (2006) characterised the definition of technology into three categories: (a) technology as hardware; (b) technology as rules; and (c) technology as system. Firstly, technology as hardware is mainly about machines (including computers, tablets, smartphones, and so forth) and tools. Secondly, technology as rules is essentially about the rules that are followed when operating the machines and working certain tools. Blackwell (2006) postulate that to comprehend technology as rules requires an understanding of a concept of "hardware" versus "software". Lastly, technology as system refers to the set of interconnected objects (hardware and

software) that transform or control materials and/or information according to certain rules for particular purposes.

In the present study, technology is defined from the educational perspective. Brückner (2015) asserts that educational technology can be defined as "the effective use of technological tools in learning. As a concept, it concerns an array of tools, such as media, machines and networking hardware, as well as considering theoretical perspectives for their effective application" (p. 1). In this modern society, educational technology includes e-learning, information and communication technology (ICT) in education, multimedia learning, instructional technology, computer-based instruction (CBI), computer assisted instruction (CAI), online education, internet-based training (IBT), virtual education and digital education (Brückner, 2015). Thus, for this study, educational technology refers to the utilization of hardware and software together with the educational theories that influence the instructional design.

2.1.3 Context of South African township and urban high schools

According to Pernegger and Godehart (2007), there is no formal definition of the term township. However, the term has been understood to refer "to the underdeveloped, usually (but not only) urban, residential areas that during Apartheid were reserved for non-whites (Africans, Coloureds and Indians) who lived near or worked in areas that were designated white only" (Pernegger & Godehart, 2007, p. 2). Although segregation in South Africa ended with the commencement of democracy in 1994, some of the township areas and other low-income housing settlements have been increasing over the past two decades.

Ladd (2008) contends that the township areas in South Africa originated from the apartheid regime which segregated people according to race. The township areas in South Africa are characterised by: (a) people of colour (Blacks, Coloureds & Indians); (b) communities with low levels of facilities; (c) low-income earning households; (d) high unemployment rate; (e) crime; and (e) poverty (Pernegger & Godehart, 2007, p. 3). Thus, the schools located in the township neighbourhood are mostly populated by learners who come from impoverished backgrounds.

As a result, Rammala (2009) argues that learner performance in schools where learners come from poor families is usually low. The study by Rammala (2009) was conducted in Limpopo township high schools in South Africa to investigate factors

causing poor learner performance. The study revealed that home environment for learners is not educationally conducive because of poverty, low-level of education for parents, families headed by children, emotional problems and high rate of unemployment in their communities. Also, the key findings of her study revealed some causative factors for poor performance in school environment to include: shortage of learner support materials, lack of basic facilities, teacher redeployment, overcrowded classes and medium of instruction which is English. In a nutshell, this depicts some of the characteristics of schools located in township areas.

Another study conducted by Naude and Meier (2019) investigated the elements of the physical learning environment which affect the teaching and learning of disadvantaged South African classrooms. The findings of their study revealed that, from the cognitive load point of view, clamour, as result of the large number of learners in the classroom, as well as clamour from the outdoor environment, contributes to the over-burden of learners' working memory, which eventually impacts adversely on learning. This is what Mawdsley, Bipath and Mawdsley (2014) refer to as dysfunctional schools. Thus, it shows that some of the schools found in township areas exhibit challenges that are different from other schools situated in other geographical parts of South Africa. Nevertheless, the understanding of the purpose of technology integration in the teaching of mathematics is significant regardless of the geographical location of the schools.

2.1.4 The purpose of integrating technology into the mathematics teaching

Over the past years the integration of the technological resources into the teaching and learning environment has been advocated globally by several stakeholders in education. Mthethwa (2015) affirms that today technology cannot completely replace the fundamental roles of a teacher in the classroom. However, technology can be integrated during the teaching process with the purpose of maximizing the experience of learning for learners. Nevertheless, Harris et al. (2009), as cited in Bester and Brand (2013), highlight that:

> The use of technology in a classroom can only be successful if pedagogical principles are taken into account. Before a teacher decides to use technology, he/she should verify pedagogically which content should be taught in differentiated ways, according to students' learning needs, which concepts are

difficult to learn, and how technology can overcome conceptual challenges (p. 4).

Therefore, it seems that the purpose of integrating technology in teaching is to enhance the lessons thereby making the concepts that are not easy for learners to grasp more comprehensible. In addition, Abramovich (2013) points out that most learners of this generation are visual learners. He maintains that with visual representations leaners may learn the content they perceive to be difficult more effectively. Similarly, Bester and Brand (2013) advocate that the use of visual technologies in teaching results in a higher degree of learning since learners are inclined to concentrate for a longer period of time.

Githua, Changeiywo and Mwangi (2018) state that the increased utilisation of technological resources, especially computers during the teaching process in the classroom has been incorporated within the agenda of improving learners' performance together with educational opportunities. Umugiraneza, Bansilal and North (2017) further argue that the teaching approaches that are innovative, such as technological simulation approaches are considered more effective compared to traditional approaches of "chalk and talk". Thus, the intention to integrate technology in the teaching and learning of mathematics is a result of an attempt to improve learners' performance in the subject. Moreover, U.S. Department of Education (2017) contends that the increasing use of technological resources is geared towards personalising learning and granting students enough options over what and how they learn in their pace; while at the same time preparing them to structure and direct their own learning for the rest of their life. Thus, this implies that technology integration has a significant impact on teaching and learning.

2.1.5 Impact of integrating technology in teaching and learning

Stols, et al. (2015) assert that while the debate regarding the integration of technology continues, many developing countries in Asia, Latin America and Africa are exploring the use of ICT tools in teaching and learning. Some researchers (Alghamdi, 2019; Heissel, 2016 & Vanlehn, 2011) state that in some cases, educational technology weakens student learning, where they point out that it harms social development and creates attention issues. In addition, Heissel (2016) emphasises that when students are not supervised during their learning using technological tools, they will be more likely to be distracted in the process of learning. Nevertheless, Bouygues

(2019) argues that debate over educational technology is not a two-sided coin. She argues that context makes a tremendous change regarding the impact of technology in teaching and learning. Similarly, Jacobse and Harskamp (2011) maintain that "different approaches may be effective for different domains and also for different groups of students" (p. 3). This therefore implies that the existing results that have emerged regarding the use of ICT tools by developed countries may not necessarily hold for developing countries like South Africa since the contexts varies, thus more research is still required in this area. For instance, Howie and Blignaut (2009), in their study regarding the use of technology, established that only 18% of mathematics teachers used technology for teaching and learning purposes. They state that teachers mainly used technology for administration purposes. This implies that there might be many other instances where teachers have the technological tools available but are not utilized optimally. As a result, this study seeks to explore the use of readily available technology by teachers in the province of KwaZulu-Natal.

2.1.5.1 Learner attitudes when taught using technological tools

There are different factors that affect learners' attitude towards the learning of mathematics. Janier, Shafie, and Ahmad (2012) argue that learners experience challenges in studying mathematics because they are expected to demonstrate an understanding of different concepts and be able to memorize proofs and formulae. Learners do not perform poor in mathematics because of its complex nature, however, Fabian, Topping and Barron (2018) states that attitude is one of the main reasons why learning mathematics for learners is difficult. Thus, the argument by Fabian et al. (2018) implies that mathematics teachers are supposed to not only conduct lessons and deal with content distinctly. However, learners' attitude towards the subject must be dealt with equally. Willacy and Calder (2017) propose that integrating technology during instruction is one way of dealing with learners' attitude towards mathematics because the environment of learning affects learners' behaviour and hence, their attitude.

According to Janier, Shafie, and Ahmad (2012), technological tools such as computers, calculators and overhead projectors for visual displays show an improvement impacts on learner's attitudes towards learning mathematics. On the contrary, according to Khobo (2015), the teaching methods utilized by teachers of being transmitters of knowledge together with textbook-based teaching may make

learners develop a negative attitude towards mathematics. Therefore, when evaluating learners' attitude towards the learning of mathematics one ought to as well investigate the teaching methods that are being used by the teachers.

Correspondingly, the findings of De Vita, Vershaffel, and Elen's (2014) study on the interactive whiteboards (IWBs) in mathematics teaching, indicated that the (IWBs) can be utilized to focus on the development of particular mathematical concepts in order to better improve mathematical knowledge and understanding for students. They further established that learners demonstrated a positive feedback regarding the use of (IWBs) and they stressed that the technological tools assisted them to pay good attention during the lessons because of the exposure to a wide range of (IWB) features.

Radović, Marić and Passey (2019), in their research, established that when used appropriately, technology can assist teachers and/or tutors to provide immediate and reliable feedback to learners, thus creating a better and more interactive environment for learning. In addition, Walker, et al. (2012) state that when technology is used effectively in the classroom setting, it can create an enjoyable environment for learners with authentic examples when dealing with mathematical problems, while enabling deeper and more direct mathematics experience. In another study, it was reported that in a case where learners were working with computers and being taught through an assistance of a systematic medium, they were more able to concentrate on patterns and connections between multiple representations (Kitchen & Berk, 2016). In a similar way, the U.S. Department of Education (2017) argues that, when carefully outlined and keenly connected, innovation can quicken, increase, and extend the effect of successful instructing practices. Nevertheless, Radović, Marić and Passey (2019) contend that, in as much as the integration of technology in a classroom environment can have a positive impact on mathematics teaching, it does not necessarily imply that the integration is straightforward and easy for all teachers.

2.1.5.2 Learner performance when taught using technological tools

Hanımoğlu (2018) argues that technological tools are essential to both learners and teachers as they ease and promote better understanding of mathematics as a subject that is regarded as abstract and not easy to understand by most learners. Correspondingly, Borokhovski, Bernard, Tamim and Schmid (2016) assert that for

many developed countries the integration of technology into the teaching and learning system has become a main objective since it improves learner achievement.

Chauhan (2016) conducted a meta-analysis study of the impact of technology on learning using 122 peer-reviewed research papers where she established that technology results to effective learning for students when used appropriately. She further stipulates that effectiveness of integrating technology is high for extensive intervention duration, thus learners are prone to perform well in such cases.

Another meta-analysis study conducted by Tamim, Bernard, Borokhovski, Abrami and Schmid (2011) which consisted of 1,055 primary research studies focused on addressing the effects of technological tools on learner's achievement in a formal classroom environment. The results from their analysis demonstrated that a typical learner from a technology integrated classroom performed 12 percentile points greater than a typical learner from a traditional classroom setting where technology was not integrated to enhance the teaching and learning process.

Ogunrinade, Ogbonnaya and Akintade (2016) investigated the effectiveness of computer assisted instruction (CAI) on learners' achievement in solid geometry in Nigeria. There were 160 secondary school learners who participated in their study. The participants were then divided into experimental and control group. The findings from their investigation revealed that the CAI has the potential of not only improving learners' academic performance in solid geometry, but also impacts their attitude towards the subject mathematics.

Mthethwa (2015) carried out an investigation on the effect of an application of GeoGebra on Euclidean geometry in rural high schools in uMkhanyakude district. The statistical results from this study indicated that both control and experimental groups displayed an increase in their performance. However, the experimental group where there was an integration of technology yielded much greater levels of improvement in terms of academic performance scores. Thus, Mthethwa (2015) affirms that through the proper application of technological tools, learners can demonstrate an increase in performance levels. Thus, it seems teacher knowledge regarding the use of technology when teaching, plays a significant role in the impact of technology integration during instruction.

2.1.6 Teacher knowledge on the usage of technology

Numerous studies have shown that technology have the potential of making a significant contribution to the teaching and learning of mathematics (Chauhan, 2016; Hanımoğlu, 2018; Mamali, 2015; Mthethwa 2015; Ogunrinade, Ogbonnaya, & Akintade, 2016; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). However, Stols, et al. (2015) argues that some teachers experience challenges with the integration of technology. They assert that owing to several factors, many South African teachers who have access to the internet and other technological resources often forbear from utilising available resources to improve the quality of teaching and learning. For instance, Saal (2017) affirm that one of the major barriers that exist within most South African teachers is that of the lack of competence to utilise technology during instruction in the classroom.

Ojo and Adu (2018) conducted a study on effectiveness of ICTs in teaching and learning in secondary schools in the Eastern Cape Province. The findings of the study indicated that a small percentage of schools ineffectively integrated technology into the process of teaching and learning and the high percentage did not implement technology. Ojo and Adu (2018) outline that "most of the facilities available in Eastern Cape high schools are not really being utilized by the teachers and the students for the purpose expected" (p. 8). The study further revealed that most teachers lacked on the knowledge of how to integrate technology into their teaching.

In a study that was conducted by Ghavifekr, Kunjappan and Ramasamy (2016) in Malaysia, it was established that educational technology has the potential to transform the process of teaching and learning. However, Ghavifekr et al. (2016) claim that the realization of this potential may not be achieved because issues emerge when instructors are anticipated to execute changes in what may perhaps be antagonistic circumstances. They further state that teachers may have educational technology in their classrooms but experience challenges when they are to adopt these technological tools during instruction.

A large study was conducted by Amuko, Miheso and Ndeuthi (2015) in Kenya with the purpose of exploring various opportunities and challenges that influence the integration of technology in the process of teaching and learning mathematics in secondary schools in Nairobi. The results from their study revealed that teachers encounter major challenges which include the development of their own technological

knowledge and skills along with self-training in the utilisation of technology in their instruction. Their study further established that the mathematics teachers were not sufficiently trained to integrate technology in secondary schools for teaching and learning.

According to Najdabbasi and Pedaste (2014), the focus of the educational technology is to effectively integrate technological resources into the curriculum. However, Najdabbasi and Pedaste (2014) further outline that most teachers often do not make use of technology according to it affordability as it should be. They maintain that the main reasons why teachers do not use technology are typically associated to their knowledge and beliefs. Zhao (2003) on another hand note that while computers, computer programs, the Web, and other technological tools are much more advanced, they are unessential and futile until they are utilized to fathom issues that instructors experience in their teaching. He further argues that unless they are utilised, technological resources remain as artifacts or man-made objects, and they only become tools as soon as they are connected to a problem.

Various research studies both nationally and internationally indicate that in as much as there is a high demand for technology integration into the schooling system, there is still a lack of skills and knowledge for teachers to meet this demand (Amuko, Miheso & Ndeuthi, 2015; Ghavifekr, Kunjappan & Ramasamy, 2016; Ojo & Adu, 2018; Saal, 2017; Stols et al., 2015). Thus, at this stage it is vital to review the kinds of specific knowledge that teachers ought to possess to be successful with their teaching.

According to Kleickmann et al. (2012, p. 1) in mathematics education, "pedagogical content knowledge (PCK) and content knowledge (CK) are key components of teacher competence that affect student progress". Shulman as cited in Kleickmann et al. (2015) assert that CK speaks to teachers' understanding of the subject matter instructed. The teacher requires not as it were get it that something is so, but the teacher must moreover understand why it is so. In this way, the accentuation is on a profound understanding of the subject matter instructed at school

In addition, Shulman (1986) state that CK can be thought of as a prerequisite for PCK. He maintains that a type of content knowledge is pedagogical knowledge, which goes past knowledge of subject matter per se to the measurement of subject matter knowledge for teaching. According to Shulman (1986), every teacher is expected to

possess this kind of knowledge so that they can flexible and effectively be able to impart subject matter knowledge. Shulman on knowledge growth in teaching further discuss 'curricular knowledge, propositional knowledge, case knowledge, knowledge of learners, and strategic knowledge' as other types of knowledge that teachers ought to possess. Ball, Hill and Bass (2005) emphasis that for mathematics teachers to be effective in their work they should demonstrate all the types of knowledge as described by Shulman.

Thus, it follows that with an increase in demand for technological resources in teaching and learning, the growth for additional type of knowledge of instruction is highly required. Therefore, Mishra and Koehler (2006) point out that teachers ought to be skilled and acquire more specialized type of knowledge in addition to the pre-existing types knowledge as defined by Shulman in order to be successful in their teaching in this modern society. Nevertheless, Jita (2018) advocates that the additional type of knowledge and skills of technological tools for teaching cannot be divorced from the content of the subject taught.

2.1.6.1 Technological Pedagogical Content Knowledge (TPCK)

Mishra and Koehler (2006) argue that over the past years with high developments of educational technologies, there has been noticeable research critiques regarding the lack of the grounding theory in the field of educational technology. Thus, Mishra and Koehler realized that in addition to content knowledge and pedagogical content knowledge there is another component of knowledge required which directly relates to technology. Hence, building from Shulman's (1986) construction of PCK, Mishra and Koehler over the period of five years formulated a model which they called Technological Pedagogical Content Knowledge (TPCK) and is now well known as technology, pedagogy, and content knowledge (TPACK) (Koehler & Mishra, 2009).

Koehler and Mishra (2008) state that TPCK is a model that emanates from "Shulman's (1987, 1986) descriptions of pedagogical content knowledge to describe how teachers' understanding of technologies and pedagogical content knowledge interact with one another to produce effective teaching with technology" (p. 12). They further avow that the model consists of three main interconnected domains of knowledge which are content, pedagogy, and technology. The Venn diagram on figure 2.1.6.1.1 represents the vital connections among critical domains of knowledge which make up TPACK.

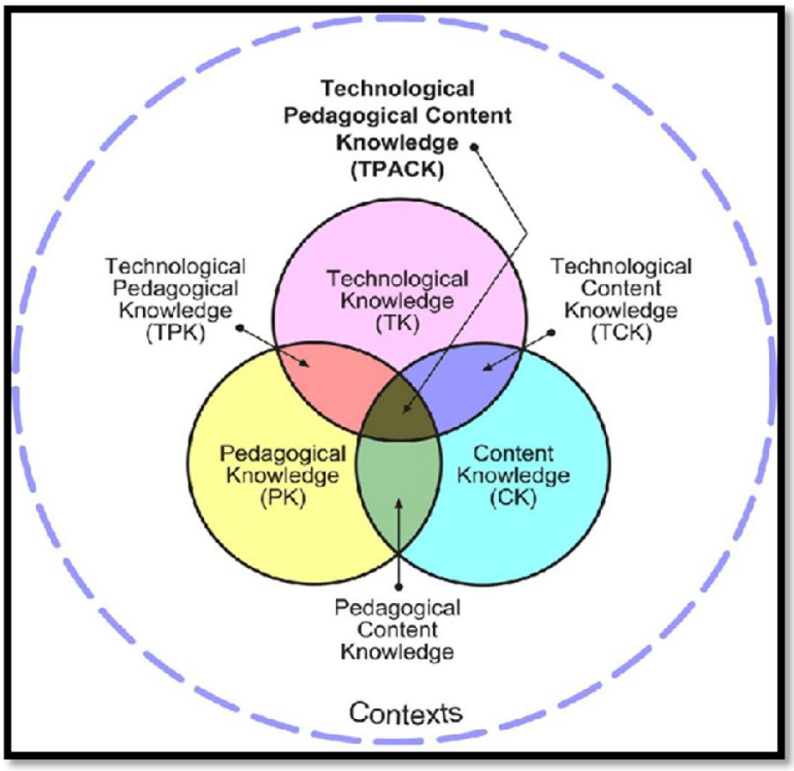


Figure 2.1.6.1.1: TPACK knowledge domains (Koehler & Mishra, 2008)

Mishra and Koehler (2006) outline that the idea of TPCK is not new since a variety of other researchers have dealt with the relationship between the concepts of technology, pedagogy and content knowledge. Bingimlas (2018) argues that the idea of TPCK has been mentioned by Niess (2005) discussing technology-enhanced PCK. Other research studies that have been done on the relationship between technology and PCK indicate that teachers demonstrated positive attitude on the domains of content and pedagogical content but there was a lack of confidence and competence on the component for the use technology during instruction (Archambault & Crippen, 2009; Bingimlas, 2018; Chai, Koh & Tsai, 2010; Koehler & Mishra, 2009).

Similarly, Adnan and Tondeur (2018) assert that TPCK encompasses base knowledge of integration of technological skills and knowledge, together with the content knowledge, knowledge of learners and pedagogy fundamental for teachers to be competent to educate with technology within the classroom. This implies that TPCK as a model is relevant in responding to the challenges that have been highlighted by different scholars (Amuko et al., 2015; Ghavifekr et al., 2016; Najdabbasi & Pedaste, 2014; Ojo & Adu, 2018; Saal, 2017) on the investigation of technological use by teachers both in primary and secondary school level.

In addition, Mishra and Koehler (2006) assert that TPACK endeavours to capture a few of the fundamental qualities of teacher knowledge required for technology integration in instructing, whereas tending to the complex, multifaceted, and arranged nature of this knowledge. They further state that the basis of TPACK as a framework for knowledge of teachers is mainly embedded on understanding that the process of teaching is a cognitive skill that is complex in nature and it occurs in a dynamic, ill-structured environment.

The framework focuses on explaining effective teaching through the integration of technological tools (Mishra and Koehler, 2006). Additionally, Koehler & Mishra (2009) claim that conducting instruction using technological tools is further complex and complicated considering the challenges that latest technologies present to teachers. Furthermore, Bingimlas (2018) state that TPACK can assist teachers and researchers in understanding the process of technology integration in teaching and learning. However, training for those who are about to or are already integrating technology is very important to ensure effectiveness. For instance, Yuen and Hew (2018) argue that an extensive ongoing training for teachers in Asian countries have been prioritized over the past few years to equip teachers with necessary skills and knowledge for effective teaching using technology. Thus, it seems the training of teachers ought to go beyond the mere training preservice teachers.

2.1.6.2 In-service teacher educator training for technology integration

Adnan and Tondeur (2018) state that in Belgium it is the responsibility of the Teacher Training Institutions (TTIs) to assist teacher educators by providing them with professional formal development programmes and learning events such as seminars and works should they be willing to develop, learn, and demonstrate effective technology integration in the classroom settings. They further advocate for information sharing sessions through mentoring, coaching and peer collaboration. In a similar way, Tondeur et al. (2017) assert that modelling in a real classroom setting is an effective method in assisting teachers to learn how to use technology. Additionally, Guzey and Roehrig (2012) state that witnessing a teacher making use of technology is an important stimulus for other teachers to want to learn to utilize technological tools in their own teaching. Thus, this implies that the process of training teachers to integrate technology in their classrooms is most likely to be successful.

In a study that was conducted in the United Kingdom on the evaluation of strategies for teacher training and support to integrate technology into the classroom, it was established that teacher training together with facilitating conditions resulted in an increase on technology use (Gamage & Tanwar, 2017). Moreover, their study revealed that if teachers are granted enough training and post training support in their use of technological tools, they become more effective in integrating technology in their classroom for teaching purposes.

According to Derbel (2017), a developing country, Tunisia, developed a project called the Tech Age Teacher Project (TATP) which aimed to "equip teachers in Tunisia with the technology skills for teaching so that they can dispense teaching of a 21st-century education quality" (p, 269). The study indicated that teachers showed extreme dedication regarding the implementation of skills and knowledge they attained from the TATP training and they could integrate technology into their instruction on daily basis irrespective of the challenges they encountered in their school settings. The study further outlined that the motivated, enthusiastic teachers' success to use technology was restricted by poor school infrastructure and "playful" attitudes by learners.

Mashile (2016) investigated the nature and extent of the integration of technology in South African schools from teacher's perspective. Among other findings of her study which outlined several challenges that teachers face when attempting to integrate technology, is that of the severe lack of professional development and training (Mashile, 2016). Her study established that the lack of training is the major barrier that South African teachers are faced with when they are intending to integrate technology. Several respondents in her study reported that they taught themselves how to use technological tools in the classroom, thus they possessed basic skills which resulted in less effective usage of the tools. Additionally, Padayachee (2017), on his snapshot survey about teachers' use of technology in teaching and learning, established that the major challenge that is common among South African teachers is that of the lack of skills. Thus, Meyer and Gent (2016) assert that teacher professional development in South Africa should be in place for initial or pre-service training as well as for in-service training and thus be an ongoing process since technology evolves rapidly.

2.1.7 Models of technology integration

In a nutshell, technology integration is about teaching a subject using technology as a tool of instruction (Misirli, 2016). Understanding what technology integration entails is important in order to know which model of integration to utilize during the process of teaching and learning. Kimmons (2016) describe technology integration models as theoretical models which are intended to assist teachers, researchers as well as other individuals in the field of education who think of educational technology in a meaningful way. Thus, Çelik (2011) argues that rather than asking the question of which and what technological tools are used in the classroom, the focus should be on how the tools are used thereby exploring the models utilised during integration. There are several models that can be adopted during teaching and learning to effectively integrate technology during instruction (Davis, 1989; Mishra & Koehler, 2006; Surry, Robinson, & Marcinkiewics, 2001). However, since there are many models of technology integration that have been developed and used, this study explores a few which, according to Kimmons (2016), are the most popular and commonly used by teachers and lecturers. The models this study explores include: SAMR, RAT, PIC-RAT and TTIPP.

According to Kimmons (2016), SAMR and RAT are models of technology integration which are very similar, except that the SAMR model is more often utilised by teachers whereas RAT is more commonly used by researchers. The idea behind both these models is that the use of technology will have impact on what is happening during the experience of learning. Thus, the models try to assist one to understand what this impact is and how to make use of technology in meaningful ways (Kimmons, 2016).

SAMR model was developed by Puentedura in 2003 and is an acronym for substitution, augmentation, modification, and redefinition. The model involves a sequence of levels or stages (Puentedura, 2014a). Substitution is the lowest level of technology integration where technology replaces all the classroom activities that may have been traditionally conducted prior to the introduction of technology. The next level is that of augmentation which assumes that improved learning experiences are a result of the use of technology which adds functionality that would have not been conceivable with traditional methods. The third level, modification, according to Puentedura (2014a), looks at teacher's reflection on whether technology allows for

significant task redesign which enhance tasks while accomplishing the learning objectives. The fourth level which is redefinition, is where teachers ought to allow students to engage on student centred learning and further investigate whether the redesign still accomplishes the desired learning standards (Puentedura, 2014a). Similarly,

> RAT is an acronym for replace, amplify, and transform and the model holds that when technology is used in a teaching setting, technology is either used to replace traditional approach to teaching, to amplify the learning that was occurring, or to transform learning in ways that were not possible without technology (Hughes, Thomas, & Scharber, 2006, p. 1620).

In Indonesia, Aprinaldi, Widiaty, and Abdullah (2018) outline that SAMR model is a popular and most utilised learning model for technology integration in vocational education. They argue that teachers using this model accordingly become successful in integrating technology into their teaching. Similarly, in Tanzania a study was conducted by Kihoza, Zlotnikova, Bada, and Kalegele (2016), that sought to assess classroom technology integration opportunities as well as challenges in relation to TPACK and SAMR models. Their case study consisted of tutors and teacher trainees from colleges that train teachers. Their study revealed that tutors had good level knowledge in all TPACK and SAMR constructs, however, teacher trainees showed inferior skills with inefficient support regarding the use of basic technological resources.

In addition to SAMR and RAT models, another model called PIC-RAT was developed for beginner teachers who intend to integrate technology into their classroom teaching and learning. According to Kimmons (2016), the basic idea of PIC-RAT model rests on two fundamental questions that a teacher ought to ask regarding the use of any technology in the classroom. The questions are: (a) "What is the students' relationship to the technology? (PIC: Passive, Interactive, Creative); (b) How is the teacher's use of technology influencing traditional practice? RAT: Replace, Amplify, Transform" (Kimmons, 2016, p. 20). This model basically focuses on students' role in the classroom when taught using technology. Figure 2.1.7.1. illustrates the relationship between students and technology used by teachers.

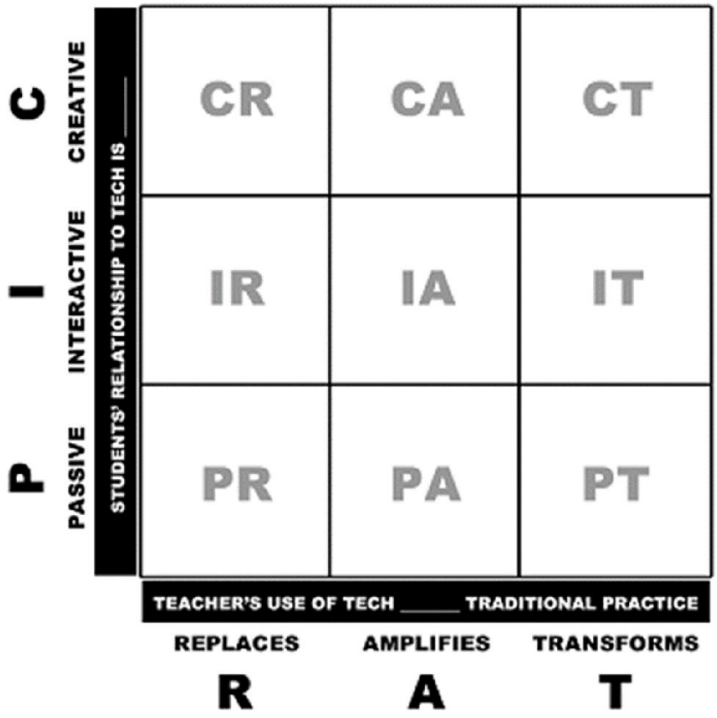


Figure 2.1.7.1: PIC – RAT model (Kimmons, 2016).

Depending on the type of technology being utilised by teachers to either replace, amplify or transform, students can be either passive (students being taught using a simple PowerPoint presentation), interactive (learning using interactive smartboards, e-learning) or creative (students engaging with technology learning material, blended learning).

The recently developed Turn-around Technology Integration Pedagogy Planning (TTIPP) model provides an approach that is comprehensive for planning the integration of technology that resolves the instructional challenges (Black, 2017, p. 50). Roblyer and Hughes (2019) describe this model as a regular process model that is

valuable when teachers choose that they would like to undertake to utilise digital technologies for teaching or on the off chance that they are confronted with necessities to utilise technology. The model consists of three phases and nine steps which offer a comprehensive, measurable and effective strategy for integrating technology during instructional practices (Black, 2017, p. 50). The first phase of the TTIPP model emphasises the need for prior planning and analysis for teaching environment beforehand. The second phase focuses on a framework for integration and the design where the emphasis is on identifying the learning objectives, while the third phase is mainly on reflecting, reviewing the implemented methods using technology (Black, 2017).

However, in South Africa, Ramorola (2013) established that there is scant evidence of the integration of technology into classroom activities such as orderly arranging and execution of lessons that require learners to think fundamentally, work collaboratively, and utilise technology to support learning. Nevertheless, the basic understanding of the utilisation of technological tools in teacher training institutions is essential at this stage.

2.1.8 The use of technological tools in teacher training institutions

In European schools, it is a minimum requirement that all newly appointed teachers ought to possess certain technological skills relevant to the subject(s) they will be teaching. European Commission (2019) outlines that in initial teacher education (ITE), technological competences are recognized from competence frameworks across European countries. According to European Commission (2019), the competence frameworks advocate that teachers ought to know how to integrate digital technologies during instruction and be able to utilise them effectively. The commission further asserts that in most European countries teacher training institutions strive to prepare pre-service teachers to be digitally competent and be able to strategically integrate educational technologies with confidence while acting as role models of the future industrial revolution generation. Thus, it seems that in Europe pre-services teachers are equipped with essential specific pedagogical content knowledge of educational technologies.

Graziano, Foulger, Schmidt-Crawford and Slykhuis (2017) conducted a study in the United States that discussed the development of common technological skills which guide teachers in conducting instruction with and about technology. In their

paper, they argue that pre-service teachers ought to be prepared enough to teach using technology on the first day when they get into the classroom. Additionally, Graziano et al. (2017) advocate that university instructors ought to be role models for pre-service teachers in the utilisation of technology when teaching and offer support in developing the pre-service teachers' ability to integrate technology. However, if pre-service teachers are not exposed to the utilisation of technology during their training, they should not be expected to make use of educational technologies when they get to the classroom (Rimini & Spiezia, 2016).

Moreover, Shonfeld and Goldstein (2013) conducted research in Israel colleges of education to examine pre-service teachers' preparation to conduct classroom instructions with technology. Their study revealed a significant problem of 75% of graduates who did not practice technology-based teaching in their classroom teaching. The results of their study further revealed that the Israel college supervisors offered minimal technology training for the in-service teachers. Thus, their graduates were exposed predominantly to traditional ways of technology integration, such as the utilisation of the Internet, emails and online submission of assessments (Shonfeld & Goldstein, 2013). However, their findings impacted on decisions made by the policy makers on the programme to transform the colleges to meet the 21st century demands. The program initiated by the Israel Ministry of Education focused on preparing pre-service teachers at colleges to develop pedagogical innovations in effective technology integration.

Another study was conducted by Aslan and Zhu (2015) in Turkish state universities to identify the perceptions of elementary mathematics and science pre-service teachers on the integration of educational technologies. The data from the 782 pre-service teachers revealed a positive feedback from the participants, even though several concerns and suggestions were articulated. Their study indicated that some of the Turkish state universities had challenges with infrastructure. Therefore, a certain percentage of the participants stated that there is a shortage of technological resources at their universities, thus, they are not exposed to proper integration of educational technologies during teaching and learning. Furthermore, the participants suggested that the course hours for teaching technology integration of the content knowledge ought to be extended and be more practical. In addition, the participants indicated that these types of courses should be offered in a more detailed and effective manner. They

further outlined that the university instructors ought to be more competent with technology integration during instruction (Aslan & Zhu, 2015). This issue is significant in the sense that academics' competency in ICT integration influences the type of teachers the universities produce.

Also, Kisalama and Kafyulilo (2012) conducted a study on the integration of technology at Makerere University in Uganda and University of Dar es salaam in Tanzania. Their study sought to establish ways in which educational technologies were deployed in training pre-service mathematics and science teachers in the two universities. The findings of their study revealed that lecturers as well as pre-service teachers had limited knowledge and ability of technology integration. Thus, for both universities, lecturers and pre-service mathematics and science teachers demonstrated poor technological pedagogical content knowledge. Kisalama and Kafyulilo (2012) assert that pre-service teachers had the basic technological knowledge together with all the theoretical knowledge of technology, however, they had no practical experience of how to apply that knowledge in a classroom context. With these two universities, the lack of competency in technology integration among pre-service teachers was due to ill-structured courses offered at the universities, lecturers' incompetency in using technological tools and the shortage of resources.

The Department of Basic Education (DBE) in South Africa has recognized the importance of the use of technology in teaching and learning. DBE (2018) states that "the need to incorporate ICT in the classroom has been identified" (p. 83). However, the department has not put forward a tenable action plan that outlines how the integration of technology is to be implemented across the country. Thus, several studies (Jita, 2018; Khobo, 2015; Mashile 2016; Padayachee 2017; Stols, 2007) have been conducted to establish the use of educational technology in South African schools and teacher training institutions. For instance, Jita (2016) conducted a study about the integration of technology in one of the universities in South Africa. Her study established that the final year pre-service teachers in their teaching practices barely used the technological tools that were available at their disposal. However, her study revealed that these pre-service teachers were exposed to the teaching and learning using technological tools by their instructors, but they were not confident to make use of these tools in their own teaching.

2.1.9 Availability of technological resources in South african schools

Padayachee (2017) conducted a snapshot study on the integration of ICT tools by teachers in South African. The study revealed several issues and challenges that teachers encounter in their attempt to make use of technology in the classrooms. Padayachee (2017) argues that in the field of education in South Africa, there is still a lack of technological infrastructure within most schools. Thus, in some cases teachers may possess skills and knowledge to integrate technological tools into their teaching but be disadvantaged by the shortage of such tools in their teaching space.

In addition, Mukhari (2016), in her study, established that one of the major challenges that affect the effective use of technology in South African schools include "barriers which include lack of access to computers in working condition, lack of software and technical support, insufficient teacher training, lack of internet access, lack of reliable electricity supply and lack of parent and community involvement" (p. 95). Similarly, Laaria (2013b) asserts that some factors that impact on the use of technology by teachers in developing countries like South Africa are the cost of technological tools, poor infrastructure and maintenance, inadequately trained teachers on technology use, dissatisfaction with the introduction of technology and unreliable power sources among others.

2.1.10 Summary and Implications

The literature that was reviewed for the purpose of this study has shown that there is significant difference in South Africa between schools located in township and urban areas. Since literature points out that mathematics is a problematic subject for both learners and some teachers. Numerous studies (Abramovich, 2013; Bester & Brand, 2013; Githua, Changeiywo & Mwangi, 2018; Umugiraneza, Bansilal & North, 2017) outlined that the purpose of integrating technology in mathematics teaching is to enhance the lessons thereby making the concepts that are not easy for learners to grasp more comprehensible. In addition, the literature that was reviewed in this chapter revealed that the effective use of technology during teaching and learning has a positive impact.

However, literature showed that in most developing countries like South Africa there is still a lack of teacher knowledge on the use of technology to conduct instruction. Furthermore, the literature revealed that some teachers using technology

today were not trained on how to integrate them, but they taught themselves. Nevertheless, some countries have certain programmes that are run in schools to train in-service teachers to be able to integrate technology in their teaching. In addition, recent literature has outlined that pre-service mathematics teachers from some teacher training institutions get some form of training on how to integrate technology during their teaching. However, from the review of literature, it was established that even after being trained, some teachers still do not make use of available technological resources. Another challenge that was revealed by literature is that schools in developing countries have a lack of these resources, which hinders teachers with knowledge and skills from applying their skills.

What was notable from the reviewed literature is that there was not enough evidence on whether mathematics teachers from the South African schools with technological tools integrate them effectively, if they ever integrate. Thus, this study seeks to explore the integration of technology by mathematics teachers in KwaZulu-Natal province in South Africa. The next section of this chapter discusses the theoretical framework that underpins this study.

2.2 THEORETICAL FRAMEWORK

The previous section of this chapter presented the review of the literature that assisted in identifying a gap in research regarding the use of technological resources by South African teachers. This section discusses the lenses through which this study responded to the main research questions and discussed the findings thereof. The section seeks to define and explicate the relevance of the chosen theoretical framework to the context of the current study.

2.2.1 Technology Acceptance Model

This study is underpinned by the Technology Acceptance Model (TAM) framework which was coined by Fred Davis, the proponent in the Information Systems and Technology (IS&T) research department. Technology Acceptance Model (TAM) has been used by researchers mainly in the field of Information Systems and Technology to explicate the implementation of the newly developed systems and other information technologies.

Davis (1989) outlined that TAM elucidate the aspects impacting the use of ICT grounded on the theory of reasoned action (TRA) by Fishbein and Ajzen (1975) and the theory of planned behaviour by Ajzen (1985), where the theory of TAM extended to include the concepts of perceived ease of use and perceived usefulness. Thus, according to Surej (2015), beliefs pertaining to usefulness and ease of use of a technological tool by individuals are regarded as major determinants for technology adoption. Kwok and Yang (2017) also point out that these two major determinants directly influence individuals' intention to utilise new technologies presented to them. In addition, Saleh and Drew (2014) maintain that the TAM framework has been developed to establish the extent to which the end-user comes to accept and utilise a technological resource.

Recently, the TAM is utilised in mathematics education research for the same purpose because of the use of technological tools for teaching and learning (Lopez, 2007; Stols, 2007; Torun & Usluel, 2007; Weng, Yang, Ho, & Su, 2018). Wong (2015) conducted a study that sought to understand the acceptance of technology by pre-service mathematics teachers in Hong Kong. He advocates that elements of technology acceptance model assist in establishing the extent to which teachers accept the adoption of educational technology in their teaching. Similarly, Granić and Marangunić (2019) assert that the TAM framework in teaching and learning context has become a key model as it assists in comprehending predictors in human behaviour regarding the potential acceptance or rejection of technological tools. Thus, in conducting the current study which seeks to explore the integration of readily available technological tools by mathematics teachers, the TAM framework has been recognized as being relevant to responding to the main research questions and for analysing data. Iqbal and Bhatti (2015) affirm that the TAM framework is the prevalent choice among the researchers for examining acknowledgment of any modern technology fundamentally because of its vigorous and miserly nature. Nair and Das (2012, p. 1) assert that:

> TAM , based on the Theory of Reasoned Action, is a simple model of IT adoption that claims that the overall IT acceptance or utilization is based on users' beliefs like (a) system's perceived usefulness (PU) and (b) systems' perceived ease-of-use (PEOU), which are the major impact factors for their (c) attitude towards use (ATT) and also (d) Behavioural Intentions to use (BI).

Figure 2.2.1.1. illustrates the relationship between the determinants of the framework as defined by Davis.

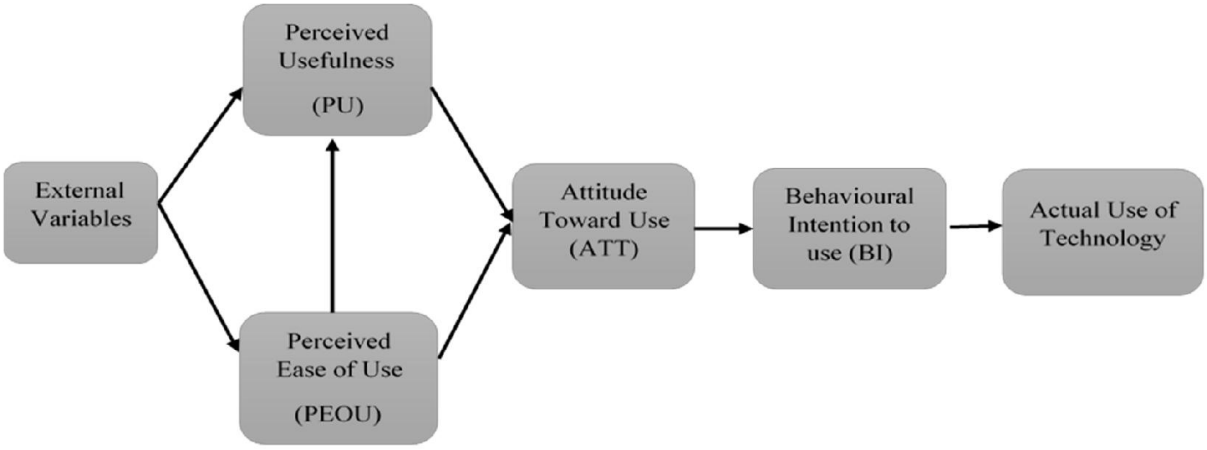


Figure 2.2.1.1: TAM model (Nair & Das, 2012).

Davis (1989) claims that there are many variables which influence people's decisions to either accept or reject new technologies in their working environment. He states that these can be narrowed to two major determinants which are perceived ease of use and perceived usefulness. Taherdoost (2018) argues that these two determinants were included in the TAM to improve adaptively, illustrative control, and specificity. In addition, while investigating the different factors that affect the actual use of technological resources, it was further established that there are other variables which ought to be considered prior to focusing at perceived usefulness and ease of use. Thus, the two components of internal and external variables were proposed by Saleh and Drew (2014) to form part of the framework.

According to Saleh and Drew (2014), the internal variables include the pedagogical beliefs as well as the attitude that users hold regarding the use of technology. These scholars argue that positive attitude towards starting to use technology has the potential to motivate teachers to integrate technology in their teaching. On the other hand, the external factors include the outside barriers that hinder users with the intention to make use of technology (Saleh & Drew, 2014). They further assert that the external factors may include the shortage of technological resources, lack of skills and knowledge and other social barriers. In addition, Mberia, Ofafa, Muathe and Muli (2013) outline that other factors like computer self-efficacy and gender, are also useful in predicting the usage of technological resources.

Figure 2.2.1.2. illustrates the TAM model showing how external factors may affect the actual use of technology.

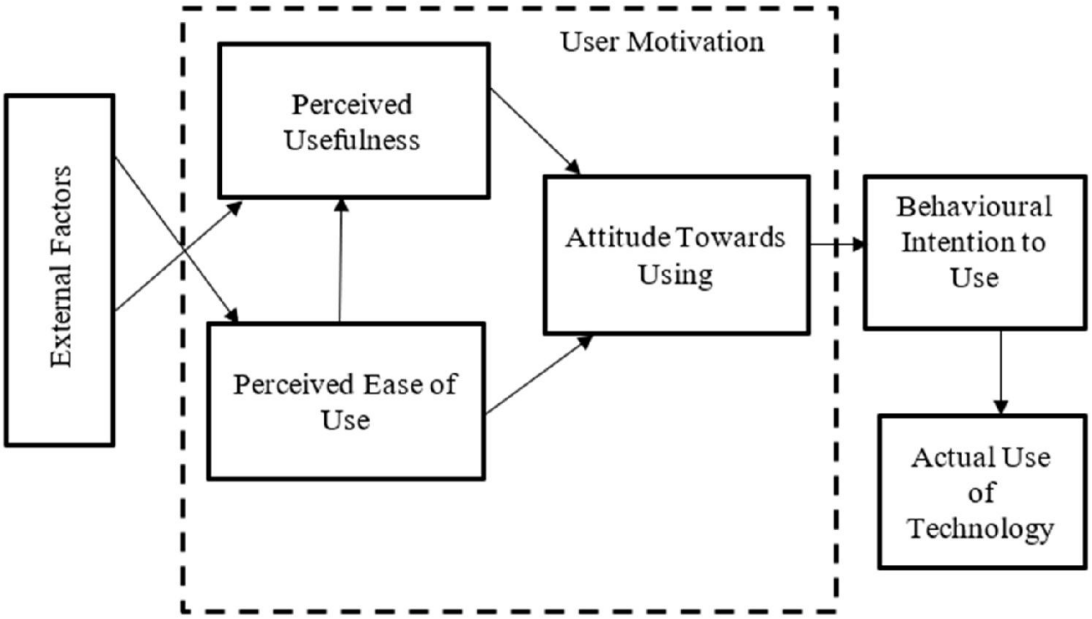


Figure 2.2.1.2: TAM model

2.2.1.1 Perceived Ease of Use

According to Davis (1989), the degree at which an individual is convinced that making use of particular technological system would be effortless and free of mental effort is regarded as an underlying factor for perceived ease of use. This follows from the meaning of the word "ease" which means "lack of difficulty or excessive effort" (Oxford Advanced Dictionary, 2010, p. 462). Similarly, in an educational setting when teachers are presented with educational technology and foresee minimal hassle in integrating that educational technology, it can be concluded that they perceive it as being easy to use (Mugo, Njagi, Chemwei, & Motanya, 2017). Kumar and Daniel (2015), from their study, established that especially in the teaching environment, time is the major factor that affects teachers' ease of use of educational technologies. They further argue that the intention to use and attitude towards educational technologies highly impact on the determinant of perceived ease of use.

2.2.1.2 Perceived Usefulness

Perceived usefulness, on the other hand, is the determinant of technology integration which is regarded as the degree to which a person believes that a certain technological resource has the potential to improve his/her performance for a particular

job (Davis, 1989). This understanding of perceived usefulness is derived from the meaning of the term useful: "helpful for doing or achieving something advantageously" (Oxford Advanced Dictionary, 2010, p. 700). The perceived usefulness, according to Davis (1989), has a direct impact on the acceptance of technology usage. Thus, Stols (2007), from his study, outlines that "although perceived ease of use of technology did not directly affect user acceptance, it did via perceived usefulness" (p. 11). However, Weng, Yang, Ho, & Su (2018) claim that there is a strong relationship between perceived ease of use and perceived usefulness of technological resource. Additionally, Godoe and Johansen (2012) advocate that perceived usefulness has been often identified as the strongest determinant of the TAM model.

2.2.1.3 Attitude Towards Use

This study defines attitude as the evaluation of a new object (technological tool) by an individual (Fishbein & Ajzen, 1975). According to Davis (1989), the attitude determinant in the TAM model is the mediator between the first two elements (perceived ease of use and perceived usefulness) and behavioural intention to use. Lai (2017) points out that attitude towards use was later seen by Venkatesh and Davis (1996) as being a weak element that may not be reliable to conclude on the acceptance of the use of technology. Thus, Lai (2017) outlines that the attitude determinant was excluded by other scholars from the model owing to its weakness as a mediator. He further states that this was done depending on the nature of the study being conducted.

Venkatesh and Davis (2000) also assert that by omitting attitude towards use, the model theorized a rather direct relationship between intention to use and the constructs. Nevertheless, Kwok and Yang (2017) contend that perceived ease of use and usefulness are the vital determinants in establishing users' attitude toward the use thereby predicting their intention to use and integrate. Thus, for the purpose of this study, the Davis (1989) version of the TAM model was adopted because of its relevance to the context of the current study.

2.2.1.4 Behavioural intension to Use

Behaviour, for the purpose of this study, is understood to mean a result of or intention to execute some action based on particular stimulus (Fishbein & Ajzen, 1975). TAM as a model underpinned by the theory of reasoned action (TRA) by

Fishbein and Ajzen (1975), “assumes that human behaviour is the outcome led by behavioural intentions” (Sivo, Ku, & Acharya, 2018, p. 74). It is also based on the theory of planned behaviour TPB as established by Ajzen (1995) which is an extension of TRA that incorporates additional determinant of perceived behavioural control on behavioural intentions of users. In addition, Sivo, Ku, and Acharya (2018) assert that TPB presumes “that when people believe they are in control of their own behaviour, their intention to perform that behaviour will likely increase whether or not their attitudes about that behaviour are favourable” (p. 74).

Additionally, Matikiti (2018) claims that people’s behaviour is speculated using the perceived usefulness and ease of use determinants. Thus, behavioural intention to use technology is a key determinant for the adoption of a technological resource. Furthermore, Ajibade (2018) adds that behavioural intentions ought to be utilised to speculate the teachers’ actual use of technological resources.

2.2.1.5 Actual Use of Technology

The actual use of technology is dominantly influenced by the external variables, perceived ease of use, perceived usefulness, attitude towards use and behavioural intention. Actual use of technology by users cannot be evidenced without the above discussed variables and determinants.

2.3 CONCLUSION

The literature review and theoretical framework that was employed as a lens for responding to the study’s main research questions and analyse data, has been discussed in this chapter. The framework has been found to be fitting and reliable in analysing the findings of this study because of its relevance to this enquiry. The succeeding chapter attempts to deliberate on the methodological approach relevant to this study.

Chapter 3: Research Design

3.1 INTRODUCTION

In the previous chapter, the literature pertinent to this study as well as the theory that framed the study were discussed. From the review of the literature, scholars have argued that the integration of technology into the classroom instruction aids teachers to enhance their lessons whilst fostering learner engagement and thus, increasing the chances of success in learner achievement in mathematics. Furthermore, the reviewed literature further revealed that there are some challenges that teachers encounter in their attempt to integrate technology in their teaching.

Hence, the primary aim of this research is to explore the teacher's usage of technological tools that they have at their disposal. In order to achieve its purpose, this study addresses the following main research questions:

- What are teachers' opinions on the use of technological tools in the teaching of mathematics?
- How do mathematics teachers integrate available technology into the teaching of mathematics?
- What are the challenges that mathematics teachers encounter in the process of implementing technology into their teaching and how do they deal with such challenges?
- How is technology contributing to the teaching of mathematics?

This study was guided by the TAM framework as it introduced the fundamental technology acceptance through measurement and intepretation of percieved ease of use, pervieved usefulness, and intenttion to use. Leedy and Ormrod (2005) assert that research methodology can be defined as "the general approach the researcher takes in carrying out the research project; to some extent, this approach dictates the particular tools the researcher selects" (p. 12). In a similar way, Rajasekar, Philominathan and Chinnathambi (2013) state that the strategies by which researchers go about their work of depicting, clarifying and anticipating marvels are called research methodology.

Thus, according to this study, research methodology is mainly about the procedures or nonlinear step-by-step process that ought to be followed in the development of a research study.

The current chapter discusses the research methodology of this study. Herein, the paradigm, the research design, the geographical location where data were collected, the population together with the sample of the population and sampling methods are discussed. In addition, this chapter further deliberates on the methods of data collection, data analysis and ethical issues.

3.2 RESEARCH PARADIGM AND APPROACH

3.2.1 Research Paradigm

According to Bertram and Christiansen (2014), "a research paradigm represents a particular worldview that defines, for the researchers who hold this view, what is acceptable to research and how this should be done" (p. 24). In addition, Kivunja and Kuyini (2017) add that the term paradigm in educational research is utilised in describing researcher's view of the world. They further stipulate that "this worldview is the perspective, or thinking, or school of thought, or set of shared beliefs, that informs the meaning or interpretation of research data" (p. 26). Bertram and Christiansen (2014) emphasise that working within a certain paradigm informs the researcher of the following: the type of questions that must be asked; variables that can be investigated and observed; the manner in which data is to be collected and how to interpret the findings.

Thus, Mackenzie and Knipe (2006) assert that there are different worldviews or conceptual lenses through which researchers can locate their research projects in and ascertain the methods of research that will be utilized in their projects. The most commonly used worldviews or paradigms as outlined by Kumar (2011) are: (a) postpositivism, where researchers assume that there is only one truth about social events which cannot be known completely, (b) interpretivism, which assumes that there is more than one truth based on many interpretations of events about social world, and (c) critical paradigm, where researchers see reality as shaped by cultural, political, economic, social and other dynamics which exhibit unequal power relations.

Therefore, in order to be able to accurately respond to the main research questions asked in this study, the study employed the interpretive paradigm, the reason

being that the main objective of the study was to explore and understand the teachers' usage of technology in the teaching of mathematics. Moreover, Lewis (2015) states that the purpose of the interpretive paradigm is to elicit thick understandings of how humans make sense of reality based on the contexts in which they find themselves. In addition, Crofts, Madden, Franks and James (2011), as cited by Mthethwa (2015), advocate that "the aim of interpretivism is to understand the subjective experiences of those being studied, how they think and feel and how they act or react in their habitual contexts" (p. 53). Furthermore, Lincoln and Guba (2000) add that for the interpretivists, researcher's interpretations are attained with the purpose of comprehending human attitudes, behaviour, perceptions and beliefs. They state further that the interaction between the researcher and the participants is subjective within this paradigm. Therefore, the reason for adopting the interpretive paradigm is that this study sought to explore teachers' responses based on their own lived experiences regarding their exposure to technological resources at their disposal. The adopted paradigm was also identified as being fit for collecting and interpreting the findings of the current study.

3.2.2 Research Approach

Kumar (2011) states that the strategy and plan of investigation considered to be useful in obtaining answers to the main research questions or problems in any study defines the research design of the study. In addition, research design is an arrangement of conditions that assist for the collection and analysis of data in a manner that is relevant to the purpose of the research study (Kumar, 2011). Creswell (2014) states that there are different research approaches that shape and determine the instruments for collecting and analysing data. This scholar further adds that the choice of the research approach to be adopted by a researcher depends on both the research paradigm and the critical questions s/he seeks to answer. It is however important to note that different types of research approaches have their own distinctive features that define them. Thus, a particular research approach is adopted based on the knowledge about these characteristics and the purpose of the study.

According to Williams (2007), three main research approaches are commonly utilised by researchers. Firstly, researchers can opt for a quantitative research approach that is mainly grounded within the positivism or postpositivism worldview. This type of research approach mainly uses true or less rigorous experiments to test or confirm

assumptions and theories. In a nutshell, quantitative strategies seek to provide numeric and statistical descriptions or to determine if a certain treatment has an impact on specific outcomes (Creswell, 2009).

Secondly, depending on the nature of the study, researchers can choose to utilise qualitative research approach that is grounded within the interpretivism worldview. Kumar (2011) outlines that "the main focus in qualitative research is to understand, explain, explore, discover and clarify situations, feelings, perceptions, attitudes, values, beliefs and experiences of an individual or group of people" (p. 104). Creswell (2014) argues that the process of data collection using qualitative and quantitative research approach are similar. However, the qualitative research approach relies on text and image data where the steps for data analysis differ from quantitative approach. Thirdly, Williams (2007), asserts that a mixed methods research approach may be utilised for studies with research questions requiring both numerical and textual data.

Since the purpose of this study is to explore and understand the phenomenon in question, the qualitative research approach was deemed relevant to collect and analyse data for the present study. The main reason for adopting a qualitative research approach was that this study sought to explore the phenomenon from the participants' perspective in their natural setting. The research approach adopted is in accordance with the framework with which this study underpinned.

3.3 RESEARCH STYLE

Bertram and Christiansen (2014) assert that there is a variety of research styles that can be utilized when conducting research. They argue that the style of research to be used when conducting any type of research is usually influenced by a number of factors including: research questions and objectives, methods of data collection and research paradigm a researcher is working within. For this research study, an exploration about a group of mathematics teachers' experiences on the use of technology when teaching is being carried out. Thus, the case study design best fit for the present study. Cohen, Manion and Morrison (2005) attest to the use of the case study as an effective design particularly in social science and educational research.

Karlsson (2016) points out that defining a case study means different things to different people. However, this thesis privileged Rule and John's (2011) definition that a case study is an in-depth systematic study pertaining to a specific case in its setting

where the case may be an individual (a learner, a teacher, a principal, or a guardian), a group of individuals (a class of learners), or a community, or a school. Moreover, Cohen, Manion and Morrison (2011) outline that with a case study, the reality of lived experiences of the participants and their thoughts about certain situations is captured. Nevertheless, Zach (2006) argues that case studies have been criticised by scholars based on its rigour of approach, however, she insists that case studies can be utilised successfully to "probe beneath the surface of a situation and to provide a rich context for understanding the phenomena under study" (p. 4).

Cohen, Manion and Morrison (2005) emphasise that case studies have various types which can be determined by the purpose they serve. In addition, Stake (1995, 2005) identified three main types of case studies, namely: intrinsic, instrumental and multiple/collective case studies. Similarly, Yin (2009) categorises case studies into three types based on outcomes, they are: exploratory, descriptive, and explanatory case studies. In addition to Stake's categorisation of case studies, Hamilton and Corbett-Whittier (2013) suggest another five types of case studies which are: reflexive, longitudinal, cumulative and collaborative case study. This therefore attests the definitional complexity of case studies as a concept. However, Cohen, Manion and Morrison (2018) put it forward that researchers' choice to adopt a particular type of a case study or a mixture of case studies for research, is informed by: the subject being studied; the purpose of the study; the approach to be used; and the process to be adopted.

For the purpose of this study, a multiple-case study design was adopted. According to Cohen, Manion and Morrison (2018), a multiple-case study design refers to a study undertaken to gain more general or fuller picture of groups of individual case studies. The reason for using a multiple-case study design is that this study sought to explore the integration of technology by several participants (teachers) from 10 schools. Thus, the participants from different schools could not be treated as a single case, though they may exhibit some similar characteristics. Therefore, each school was treated as a case, thus forming 10 separate cases.

Moreover, Stake (2006) notes that in multiple-case study design "the cases need to be similar in some ways; perhaps a set of teachers, staff development sessions, clinics, or airport security stations" (p. 1). Also, Zach (2006) asserts that most of the case study research focuses on a single case because of its unique characteristics.

Multiple-case studies on the other hand permits for an exploration of the phenomena being studied through the utilisation of replication strategy (Zach, 2006). To understand the strategy of replication, Yin (1994) asseverates that replication is conducted in two phases. Firstly, a literal replication phase is carried out where cases are selected to attain similar results. Secondly, a theoretical replication phase is carried out where cases are selected for exploration and confirmation or disproval of the identified patterns.

3.4 DELIMITATION AND LOCATION OF THE STUDY

The data for the current study were collected in 10 Durban secondary schools in Umlazi district in the province of KwaZulu-Natal. Of the 10 secondary schools, six are located in the township area and the other four schools are located within the suburbs of Durban. The six schools where data were collected are quintile four and are populated by only African teachers and learners. The other four schools are multiracial and are categorized under quintile five. The standard of living within the areas where schools are located varies. However, all the 10 schools were adopted by one of the private South African companies. Despite the different backgrounds of the schools, they were all provided with one of the latest sophisticated technological tools to be used for teaching and learning of mathematics and science. Initially, 15 schools were chosen to be involved in this study because they were identified as the only schools who have technological tools at their disposal. However, five of these schools could not be reached to participate in this study because the principals of these schools did not allow for their schools to be research site. Thus, data was collected from the sample of ten schools.

Each of these schools where data was collected has two classes which are fully equipped with technological resources for teaching and learning. The resources were donated by a private South African company with the purpose of improving the mathematics and science results. These tools included a smartboard, laptop with notebook software installed, a soundbar, and a dummy pen to use on the board.

3.5 POPULATION AND THE SAMPLE OF THE POPULATION

According to Asiamah (2017), the population of any study can be understood as consisting of: (a) target population which refers to the group of individuals to whom research results apply; (b) study population which consists only of individuals who

meet operational definition of the target population; and (c) research sample which consists of the actual participants from whom data is collected. The population target for this study is defined to include pure mathematics teachers in the Umlazi district in the province of KwaZulu-Natal. However, for the purpose of this study, the population that is accessible comprised the group of mathematics teachers from the 10 schools in the district which were identified to have technological resources available. Langkos (2015) opines that "a study may entail a large population which cannot all be studied. That portion of the population that is studied is called a sample of the population" (p. 4). Thus, the participants for this research were selected from the study population of 10 schools.

Therefore, a smaller group of teachers were selected from the study population of 10 schools to form a research sample with the purpose of obtaining rich qualitative data. However, Patton (2002) accentuate that there are no standard rules for the sample size of a qualitative study, it is rather informed by "the purpose of the inquiry, what's at stake, what is useful, what will have credibility, and what can be done with available time and resources" (p. 244).

Consequently, to select the participants, a purposive non-probability sampling technique was utilised because this study sought for a specific group of teachers. Non-probability sampling technique is the type of sampling whereby the individuals from the population do not get equal chances of being chosen to participate in the study (Etikan & Bala, 2017). According to Etikan and Bala (2017), a purposive sampling which is also known as judgemental sampling is "based on the judgement of the researcher as to who will provide the best information to succeed for the objectives of the study" (p. 215). In this study, mathematics teachers located in schools with technological resources, were identified as individuals who will provide the information relevant for the objectives of the study. Bertram and Christiansen (2014) contend that purposive sampling is also referred to as criterion sampling because it only picks participants who meets a particular criterion. Thus, the selection of the sample was based on whether participants met a specific criterion that was established prior to the selection. This criterion was that all the participants of the study were pure mathematics teachers located within the schools which received donation of technological tools from a particular private company. Chapter 5 of this study provides the detailed profile of the participants.

3.6 DATA COLLECTION METHODS

Kabir (2018) asserts that data collection "is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes" (p. 202). While methods of data collection vary according to discipline, the data collection element of research is common across all fields of study (Kabir, 2016). Thus, Kabir (2018) emphasises that for all data collection, the goal is on obtaining quality evidence which is then translated into rich information and produce new knowledge by providing credible answers to research question(s). In addition, Creswell (2013) contends that irrespective of the preference for defining data (qualitative or quantitative) or field of study, data collection process ought to be accurate to ensure the integrity of the research.

In addition, Bertram and Christiansen (2014) assert that there exist a variety of data collection methods which can be utilized by researchers based on their research paradigm and design. Kabir (2018) further states that the selection of data collection tools is also informed by the research questions that the study seeks to respond to. Since the current study is grounded within the interpretivism paradigm and adopted a qualitative research approach, the data collection methods that this study used are the closed-ended questionnaire, observation, document analysis and the semi-structured interview.

3.6.1 Closed-ended Questionnaire

Kumar and Daniel (2015) assert that questionnaires are equally utilized in experimental studies, survey research, social science research and other modes of observation to obtain answers from the respondents or participants. The closed-ended questionnaire was utilised as a means of collecting data for this study in order to connect background and descriptive data about teachers' use of technology when teaching mathematics. The closed-ended questionnaire used in the study consisted of dichotomous questions. Batchelder and Narens (1977) postulate that "much of the methodology in the social sciences proposes techniques for drawing conclusions from data represented in the form of answers to dichotomous (yes-no) questions (or attributes) about some domain of inquiry" (p. 113). It follows that dichotomous questions may include options like (true-false) or (agree-disagree) and so forth. For this study, the questionnaire was first piloted with a small group of science teachers

who did not participate in the study. All ten participants completed and returned the questionnaire before the observation and interview sessions. The researcher was present when the participants were completing the questionnaire and clarified where participants required clarity before responding. All questionnaire sessions were administered just before the observation. The closed-ended dichotomous questionnaire was developed from a questionnaire survey of a study that was conducted by Weng et al. (2018) to investigate the acceptance of integrated multimedia teaching tools in Chiayi County by school teachers (see Appendix D).

3.6.2 Observation

Marshall and Rossman (1989) define observation as "the systematic description of events, behaviors, and artifacts in the social setting chosen for study" (p. 79). This study did not focus on the observation of participants during their teaching. However, the focus was mainly on the physical environment observation where the investigator was observing the classroom environment where the participants conducted their teaching of mathematics in their schools with technological tools. In addition, the participants were observed during their respective lessons, though the observer only focused on the lesson presentation and not the lesson preparation. The observation schedule was not piloted. All the ten participants were observed once for a single lesson of $\pm$ 50 minutes. The observation schedule was utilised to capture the details indicated (refer to Appendix E) during the participants' lessons.

3.6.3 Document analysis

According to Bowen (2009), document analysis "is a systematic procedure for reviewing or evaluating documents, both printed and electronic (computer-based and Internet-transmitted) material" (p. 27). Document analysis like other methods of qualitative research requires an examination and interpretation of data in order to gain understanding and elicit meaning (Corbin & Strauss, 2008). Bowen (2009) asserts that documents contain words, images and graphs which are recorded without the researcher's interference. Similarly, Garba (2018) points out that in a qualitative study, documentation is concerned with data analysis in which the researcher for a specific reason, is identifying, reviewing, analysing, and interpreting pre-existing texts. The documents used for this study were analysed to explain how teachers in the South African context are supposed to integrate technology when teaching mathematics in secondary schools. The documents were systematically reviewed, interpreted and

examined to obtain an understanding of how the South African department of education expect teachers in the country to integrate technology in the classroom environment. A full description of these documents is found in Appendix F.

3.6.4 Semi-structured interview

In addition, Easwaramoorthy and Zarinpoush (2006) holds that in order to gather detailed and rich data, researchers within social science research make use of interviews which consist of open-ended questions where participants can respond freely without any limitations. Similarly, Gubrium and Holstein (2001) add that:

> interviews are an appropriate method when there is a need to collect in-depth information on people's opinions, thoughts, experiences, and feelings. Interviews are useful when the topic of inquiry relates to issues that require considerable probing (p. 85).

According to Cohen, Manion, and Morrison (2018), there several types of interviews that can be utilised to collect qualitative data. For the purpose of this study, a semi-structured interview was adopted to further collect data to respond to the main research questions. Adams (2015, p. 493) maintain that a semi-structured interview consists of a mixture of closed and open-ended questions which may be followed by the how and why questions to further probe the participants.

In accordance with the research ethics, prior to the phase of data collection, it is mandatory that the researcher apply for the permission to conduct a study. Hence, for this study, a research proposal together with the application form to conduct a study at Umlazi district was submitted to the higher degrees research office while the letters requesting permission from the ten schools' principals were sent. After obtaining ethical clearance and consent from both gatekeepers and the participants, data was first collected using the closed-ended questionnaire with the purpose of gaining a general idea regarding participants' opinions towards the usage of technology in their teaching of mathematics. Thereafter, all the ten participants were observed teaching one lesson. Subsequently, a document analysis was conducted to gain awareness pertaining to the information that teachers ought to be aware of regarding the integration of technological tools when teaching. Finally, all the 10 participants were interviewed to gain deeper insight and feedback on their overall experience of being exposed to sophisticated technological tools. The participants were interviewed one-on-one in

their respective schools. The interview session with each participant lasted approximately 35 minutes. Refer to Appendix G for the interview schedule. The reason for doing the interview after the questionnaire, observation and document analysis, was to allow the interviewer to interrogate the participant's opinions regarding the use of technology to better understand their questionnaire responses.

These instruments of data collection will allow for the obtaining of rich data related to the usage of these technological resources by mathematics teachers in their classrooms.

3.7 DATA ANALYSIS

Unlike quantitative data approach to research inquiry, the qualitative approach mainly deals with the vast amounts of descriptive data from several sources. With qualitative approach to research inquiry, Academy for Educational Development [AED] (2006) states that the analysis of data focuses on the spoken or written words, consistency and contradictions of views, context, intensity of comments as well as the trends and themes emerging within data. AED (2006) further asserts that the information from qualitative data may consist of videos, pictures, documents, transcripts, surveys, blogs, and interviews, among others. Thus, this means there are multiple forms of data collection particularly for obtaining rich qualitative data.

Flick (2013) concludes that regardless of the form of data collection, the qualitative research data can be analysed in two different approaches. One approach, according to Flick (2013), "takes a more exploratory perspective" that encourages the researcher to code and consider all data they have available. This approach allows a researcher to use their findings to shape their interpretation in different directions according to the themes that emerge from their data. This approach uses inductive reasoning to research analysis. According to Attride-Stirling (2001), this approach to data analysis is commonly referred to as thematic analysis.

With the other approach, the examination of the study's findings is done based on some pre-determined framework that reflects the aims, objectives and interests of the study (Flick, 2013). He maintains that this approach is closely associated with the programmatic research. Contrary to the grounded theory, the implications of this other approach are that the study must be underpinned by an already existing theory or concept, which allows the researcher to focus on particular responses and abandon

some. This approach, according to Pope, Ziebland and Mays (2000), is termed "framework analysis" and is aligned with deductive reasoning. This form of analysis is part of the broad family of methods of analysis which are often called content analysis (Gale, Heath, Cameron, Rashid, & Redwood, 2013).

According to Hsieh and Shannon (2005), content analysis dates to the 18th century from Scandinavia where it was utilized by researchers for both quantitative and qualitative data. However, content analysis was later used primarily to analyse qualitative textual data (in the form of transcripts or field notes). Thus, with the increase in its use for analysing textual data, the content analysis was later referred to as qualitative content analysis. Kyngas and Elo (2008) thus define the qualitative content analysis as the method of analysing visual or verbal communication messages as well as written texts. Additionally, they further state that qualitative content analysis was initially utilized as a method of analysing newspapers, magazines, articles and political speeches during the 19th century. Thus, it seems the qualitative content analysis has been most commonly utilised to analyse descriptive data.

Hsieh and Shannon (2005) add that instead of being a single method for analysing data, qualitative content analysis exhibit three different approaches: conventional, summative, or directed. The three approaches share the common goal of interpreting meaning from text data content and they adhere to the interpretive or naturalistic paradigm. Nevertheless, Hsieh and Shannon (2005) argue that the three approaches differ in schemes of coding, codes origins, and trustworthiness threats. In a nutshell, Hsieh and Shannon (2005) maintain that "in conventional content analysis, coding categories are derived directly from the text data. Whereas, a summative content analysis involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context" (p. 1277). In addition, with a directed approach, the process of analysis begins with a theory, concept or relevant pre-existing research findings as guidance for preliminary codes and themes.

Nevertheless, this study employed a thematic analysis to analyse and interpret its data. The main research questions of the study were utilised to form themes for data presentation and analysis, where some of the subthemes were framed according to the TAM framework.

3.8 TRUSTWORTHINESS

According to Lincoln and Guba (1985), trustworthiness is a fundamental issue in qualitative research which pertains to a basic question of how researchers can persuade themselves as well as their audiences that their findings are worthy of being considered and paid attention to. In addition, Nowell, Norris, White and Moules (2017) maintain that trustworthiness is basically concerned with the issues of validity and reliability of the study. Golafshani (2003) adds that validity and reliability is originally a concept used within a post-positivism paradigm to ensure credibility of instruments used to collect quantitative data. However, in qualitative studies since "the researcher is the instrument" (Patton, 2002), Golafshani (2003) outline that the concept of validity and reliability refers to the credible research where credibility of a qualitative study relies on the effort and ability of the research.

To ensure trustworthiness for this naturalistic inquiry, the four criterion areas were considered separately: credibility, transferability, dependability and confirmability.

3.8.1 Credibility

Lincoln and Guba (1985) assert that several strategies to deal with credibility include activities such as prolonged engagement, data collection triangulation and persistent observation. For this study, prior to the process of data collection, the investigator worked in the same environment as the participants of the study in a secondary school at the same district. The investigator is well immersed into the context of the participants and had spent time with them, and has to some extent learnt and understood their background. Since this is a naturalistic inquiry, the investigator sought to establish a less formal relationship with the participants to have them participate freely at their natural state without having to feel threatened by the investigator. The prolonged engagement provided the scope for the context of where data was collected.

In addition, this study collected data using four different methods of data collection for triangulation purposes. The data was first collected using the closed-ended questionnaire, to gain the background check of participants' exposure with technological tools. Thereafter, the environmental observation was conducted to get the picture of where the participants were teaching and how was the nature of the

classroom where the technological tools were located. Afterwards, the documents relating to technology integration at schools were analysed to ascertain the amount of information that teachers ought to possess regarding the integration of technology for teaching. Lastly, the participants were interviewed. All these methods were utilized to collect thick data to respond to the research questions. Webb, Campbell, Schwartz and Sechrest (1966) convey that triangulation by methods is worth doing as it makes data believable (p. 3).

Moreover, during the visits at the research cites after obtaining consent from the gatekeepers, the investigator paid considerable amount of attention to the schools' environment especially in the classrooms. Prior the interview sessions at each school, the investigator did a thorough observation of the environment where the participants conducted their teaching. The aim of the observation was to explore the teaching facilities as well as the classroom setup where the technological equipment was kept. Thus, the purpose of the observation was not on the actual content that was being taught. Consent to take the photographs of the technologically equipped classrooms was obtained from the gatekeepers and the participants in each school in order to capture the observation process.

Furthermore, before, during and after the process of inquiry for this study, the investigator had peer debriefing sessions with a disinterest peer who is knowledgeable about the current topic (Lincoln & Guba, 1985). The role of the debriefer was to first advice about the methodological and ethical matters as well as with the data collection methods and methodological design. Secondly, the debriefing sessions assisted the investigator to have the mind that is clear of emotions and feelings that would have clouded the judgement of sensible steps (Lincoln & Guba, 1985). Thus, credibility was established with these techniques.

3.8.2 Transferability

According to Nowell et al. (2017), transferability is a qualitative research concept which is mainly about the generalizability of the findings of the study. Additionally, Lincoln and Guba (1985) assert that for a reader to transfer the findings of any study, the interpretivist can only outline the purpose of the study and provide thick description of the context and time in which the inquiry was conducted. The above detailed subsections of this methodology chapter attempted to provide thick description of this inquiry. Thus, the findings of this study may be transferred to

another case exhibiting the similar characteristics should the readers find the description of the findings thick enough.

3.8.3 Dependability

Lincoln and Guba, as cited in Nowell et al. (2017), state that dependability can be ensured "when readers are able to examine the research process" (p. 3). In addition, Lincoln and Guba (1985) assert that for dependability, the study ought to be externally audited. Though external audit has its drawbacks (Lincoln & Guba, 1985), to foster accuracy for this study, a senior peer examined the research process.

3.8.4 Confirmability

Confirmability is the fourth element of ensuring trustworthiness and is established when credibility, transferability and dependability has been realised (Lincoln & Guba, 1985). Tobin and Begley (2004) assert that to achieve confirmability, the findings and interpretations of the researcher must demonstrate how interpretations and conclusions have been derived. In this study, the interpretations were clearly discussed, and the conclusions were reached based only on the data that were collected.

3.9 ETHICAL ISSUES

Ethics has to do with moral principles which govern human behaviour. In research, ethics refers to doing what is legally and morally acceptable (Bickman & Rog, 2009). Furthermore, Bickman and Rog (2009) state that research ethics are predominantly about norms of conduct which distinguish between what is wrong or right, and unacceptable and acceptable behaviour. According to Bertram and Christiansen (2014, p. 65), ethics is one of the most important considerations in research, most especially with research involving human beings and animals as participants. Mthethwa (2015) also state that "researchers are compelled to ensure that their research complies with ethical standards to protect the participants from unfair criticism that may arise from participating in the research" (p. 99). For this study, permission from the principals of the 10 schools from where data were collected was requested and granted. Furthermore, the ethical clearance letter was granted by the Humanities and Social Sciences Research Ethics Committee (HSSREC) of the University of KwaZulu-Natal to ensure that this inquiry was to be conducted in a

manner that safeguards the dignity, safety and rights of the participants. Thus, for the purpose of this interpretive study, the following ethical principles were adhered to:

3.9.1 Autonomy

According to Lincoln and Guba (1985), autonomy in a research study is concerned about the principle of informed consent which ascends from the participant's right to freedom as well as self-determination. Diener and Crandall (1978) defined informed consent as those measures for persons to decide whether or not to partake in a research study after being told its purpose and what it needs. Prior to the stage of data collection for this study, each participant was given a consent letter which clearly outlined all essential details about the study. Moreover, before signing the consent form admitting to participate in the study, the participants were aware that they were free to withdraw from the study at any point without any justification. Thus, the participants were voluntarily participating for the study.

Further, Brooks, te Riele, and Maguire (2014) recommend that consideration ought to be given to the assurance of anonymity when speaking about autonomy. For this study, the participants were informed that their identities will be protected by not revealing their personal details in the research report. Hence, pseudonyms were used to refer to the participants as well as the names of their schools. Thus, the study ensured confidentiality of participants' identities.

3.9.2 Non-maleficence

Since educational research sometimes deal with human beings, Lincoln and Guba (1985) advocate that the principle of non-maleficence is pivotal to consider in this type of research. They assert that "adopting consequentialist ethics, the research should not damage the participants physically, psychologically, emotionally, professionally, personally and so on" (p. 127). Thus, non-maleficence basically means that the research shall not inflict any type of harm on its participants. The type of questions and engagement with the participants did not harm them in any form all through the study. Furthermore, no future harm was foreseen that might be inflicted on the participants since anonymity has been ensured. Consequently, Lincoln and Guba (1985) emphasise that another way to address protection from harm and privacy is through anonymity.

3.10 CONCLUSION

This chapter captured the research methodology that was used in this study. Therefore, the research paradigm, research design, delimitation of the study, sample of the population, together with the sampling methods were discussed in this chapter. Additionally, the methods of data collection, data analysis method, trustworthiness and the ethical issues were also presented. The following chapter seeks to present the results of data that were collected.

Chapter 4: Data Presentation and Analysis

4.1 INTRODUCTION

In the preceding chapter, the methodological approach for this study was presented. This chapter presents the detailed participants' profiles and results of data that was collected from the four data sets employed in this study. The main purpose of this study was to explore the integration of technological resources by mathematics teachers in selected schools in KwaZulu-Natal. Thus, for this exploration, this study attempted to respond to the following research questions: What are teachers' experiences on the use of technological tools in the teaching of mathematics?; How do mathematics teachers integrate available technology into the teaching of mathematics?; What are the challenges that mathematics teachers encounter in the process of implementing technology into their teaching and how do they deal with such challenges?; and How is technology contributing to the teaching of mathematics?

To respond to the above research questions, this study used the closed-ended questionnaire, observation schedule, semi-structured interviews and document analysis. The interpretive paradigm guided the analysis of this study in which the findings are presented in the subjective standpoints of the participants. Using thematic analysis, the findings of this study from all data collection instruments were categorized into themes which will be discussed next. The themes discussed were formed using the main research questions with subthemes that emerged from the questionnaire that consisted of the TAM framework determinants.

Table 4.1.1 presents teacher participants' profiles which contain information about the number of years they have been teaching and the qualifications they hold. The purpose for gathering information about participants was to establish the experience they have in the teaching field.

Table 4.1.1: Participants' qualification

Teacher/Case	**School**	**Years of teaching**	**Qualification(s)**
Participant 1	A	19	Senior Teaching Diploma, B.Tech in Business Administration & BSc in Chemistry
Participant 2	B	35	B.Paed, Honours Degree, Master's Degree
Participant 3	C	13	B. Ed
Participant 4	D	4	BSc in Biochemistry & PGCE
Participant 5	E	10	B. Ed
Participant 6	F	4	B. Ed
Participant 7	G	30	Senior Teaching Diploma
Participant 8	H	33	B.Paed
Participant 9	I	23	Senior Teaching Diploma
Participant 10	J	8	B. Ed

4.2 EXPERIENCE WITH EDUCATIONAL TECHNOLOGY

The theme of experience with educational technology responded to the first research question to which this study sought to respond. Table 4.2.1 shows the summary of the participants' responses on the questionnaire they completed in order to gain their general background on their exposure to the use of educational technologies. The questionnaire was developed from a questionnaire survey of a study that was conducted by Weng et al. (2018) to investigate the acceptance of integrated multimedia teaching tools in Chiayi County by school teachers. The questionnaire was

structured according to the TAM framework to assess the following: (a) external factors affecting the use of technology by teachers; (b) system's perceived usefulness; (c) system's perceived ease of use; (d) attitude towards use; and (e) behavioural intention to use. The participants had to read the statement under each category and state whether they agree or disagree as depicted below.

Table 4.2.1: Summary of participants' responses on the questionnaire.

External Variable		**Disagree**	**Agree**
E1.	There are sufficient technological tools for my teaching and learning in my school.	4	6
E2.	There is enough institutional help for teachers to use technological tools for teaching.	6	4
E3.	My institution provides me the training I need to confidently use technological tools in teaching.	9	1
E4.	My school gives recognition to staff who use Technological tools in their teaching.	7	3
E5.	I often lack time in using technological tools in my teaching	6	4
E6.	I make use of technological tools for my teaching.	4	6
Perceived Usefulness			
Q1.	Using the technological tools in my class helps me to control the pedagogy.	5	5
Q2.	Using the technological tools in my class enhances the teaching performance.	4	6
Q3.	I find the technological tools useful in my class.	5	5
Q4.	Using technological tools makes it easier to attend to individual learners' needs.	2	8
Perceived Ease of Use			
Q5.	It is easy to become skilful at using technological tools.	1	9
Q6.	I find it easy to apply the technological tools in my class.	3	7
Q7.	Using technological tools is easy and understandable.	1	9
Q8.	Using technological tools is more flexible to teach than traditional one.	-	10
Attitude Toward Using			
Q9.	Using technological tools in class is good.	2	8
Q10.	My use of technological tools in class is favourable.	2	8
Q11.	It is a positive influence for me to use technology in class.	1	9
Q12.	I think it is valuable to use technological tools in class.	-	10
Intention to Use			

Q13.	I intend to use technological tools in my class.	-	10
Q14.	I intent to increase the occurrences of using technological tools in class.	-	10
Q15.	I intend to use technological tools to provide multi-approaches on teaching.	1	9
Q16.	I would love to use technology in my teaching of mathematics.	-	10

According to the TAM framework, there are external factors that affect the user's adoption of technological resources. Similarly, in a school context, teachers find themselves encountering some external factors that hinder them from integrating technology into their teaching. For instance, on the section for the external factors on the questionnaire for this study, responses from the participants indicated that there are different factors that affect their use of technology in their teaching of mathematics. For instance, only six of the ten participants indicated that there are sufficient technological tools for teaching in their school. The other four participants who indicated that there are insufficient technological tools, stated that it is because there are only two classrooms in the whole school that are equipped with these tools and too many teachers want to use them at the same time. However, it was observed that all the ten schools had the same equipment installed in only two classrooms, thus it can be argued that the school size had an impact on their responses. Figure 4.2.1 depicts the summary of participants' responses on the first category of external factors that are perceived to have an impact on their integration of technological tools.

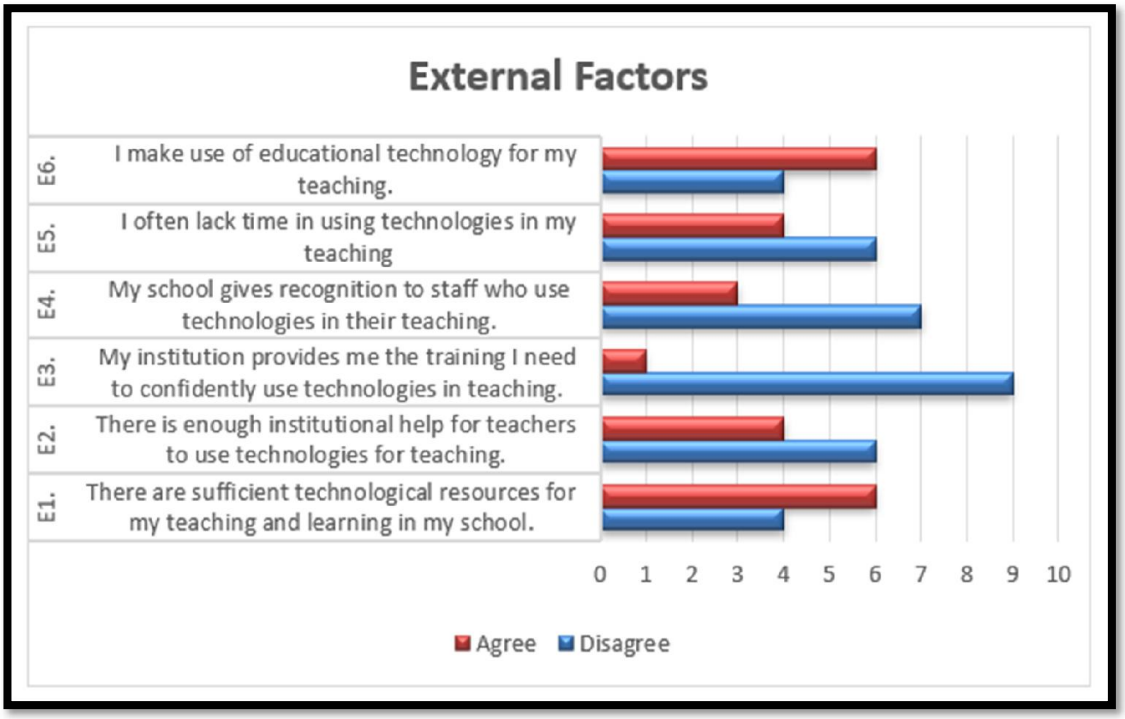


Figure 4.2.1: External factors

Six out of the ten participants indicated that there is a shortage of institutional assistance for teachers to use educational technologies. Nine of the ten participants stated that they received no training to confidently integrate technology into their teaching. For the two external factors of institutional assistance it was not clear how the participants had inconsistent responses in this regard since they were all sponsored by the same company and are within the same district. In fact, the same training was provided by the sponsor of the equipment to all teachers alike. In addition, four of the ten participants indicated that they often lack time to use technological tools in their teaching. One participant when completing the questionnaire, in response to E5, stated to the researcher that it takes time for him to setup the Smartboard system. He indicated that since their pace of teaching is always monitored, he thus resorts to traditional teaching instead. Six of the ten participants stated that they make use of technological tools for their teaching.

While this is the case, during the interview sessions all the participants indicated that they were not trained on how to integrate technology in their teaching of mathematics during their pre-service trainings. In addition, participants 1, 2, 7 and 8 stated that they were not exposed to the use of technological resources where they obtained their qualification, as they started teaching from the 1980s. Nevertheless, with the advent of technology into the teaching and learning of mathematics, they received

some basic training when they were already teaching. In response to the question: "What were your learning experiences with computers where you obtained your teaching qualification?", Participant 1 responded:

> *Okay, well, when I obtained my qualification it was a long time ago in 1984 and there were no computers at that time. So even when I started teaching in 1985 there were no computers in schools, but I was fortunate that I left teaching and went to the industry where I was exposed to the use of computers, you can mention especially Microsoft Word, Excel and using emails and so forth. That's when I was first exposed.*

Participant 8 said "*...I thank my subject advisor because he is the one who actually brought technological advances to us; to show us these things whenever we went to workshops...*". Participants 1, 2, 7 and 8 obtained their teaching qualifications when technology was not advanced or popular in the teaching and learning environment. However, as technology evolved, they became exposed to the use of technological tools. They started to adapt and, adopted the teaching of mathematics by using technology. Nevertheless, when these four participants were observed during their teaching in the classroom, only two of them actually used technology during their lesson. Participant 1, when observed during his lesson, was teaching a Geometry lesson based on space and shape to a grade 9 class through the use of Smartboard technology. This participant was fluent in the use of the Smartboard technology and learners were focused throughout the lesson even though his lesson was teacher centred. Participant 7, who also made use of technology when observed during his lesson, only projected questions on to the Smartboard and stated that he was only doing revision with his grade 12 learners. This participant stated that he normally uses technology to consolidate his lessons after having taught using traditional methods of teaching.

The other six participants 3, 4, 5, 6, 9 and 10 stated that they were exposed to the use of technological resources at the institutions where they obtained their qualifications. Nevertheless, they shared that there was no specific training that they gained from their university instructors on how to integrate technology into the teaching of mathematics. They only observed their instructors when using it. This appeared to the interviewer as their justification for not using available technological tools in their teaching of mathematics, because there are no specific courses where

teachers are directly trained to integrate technology in their teaching. Hence, participant 5, who started using technology for teaching mathematics later after becoming a qualified teacher said:

> *We did not get any training with it at the University level, I only received training when I was teaching, when I was working…so if we have sponsors, let's say there is a company sponsoring computers then they will also train us on how to use the software.*

It was noted that these six participants obtained their teaching qualifications during the 20th and 21st centuries. Thus, there were some commonalities between their cases. However, the participants had different experiences regarding their exposure to the use of technological resources. Therefore, some of them, to a certain extent, have adopted the use of technology into the teaching of mathematics. This is because they believe it can assist in making the concepts that are not easy for learners to understand more visual and easier to grasp. Nonetheless, from all the ten schools where data were collected, it was noted that teachers still rely mainly on teaching without using technology. In as much as all these schools were given technological tools for the purpose of teaching mathematics, it can be argued that teaching with these tools for some of the participants of this study is like a foreign concept that needs to be adopted and practiced.

Furthermore, the participants were interrogated on how they find the use of technological resources in their teaching. The focus was on the aspects of the perceived usefulness and perceived ease of use which are two major determinants of the TAM framework as defined by Davis (1989). The questionnaire and interview responses revealed that all the participants who have used any type of educational technology have found it useful in their teaching of mathematics. Figure 4.2.2 graphically represents the summary of participants' responses about the determinant of the perceived usefulness of technological tools.

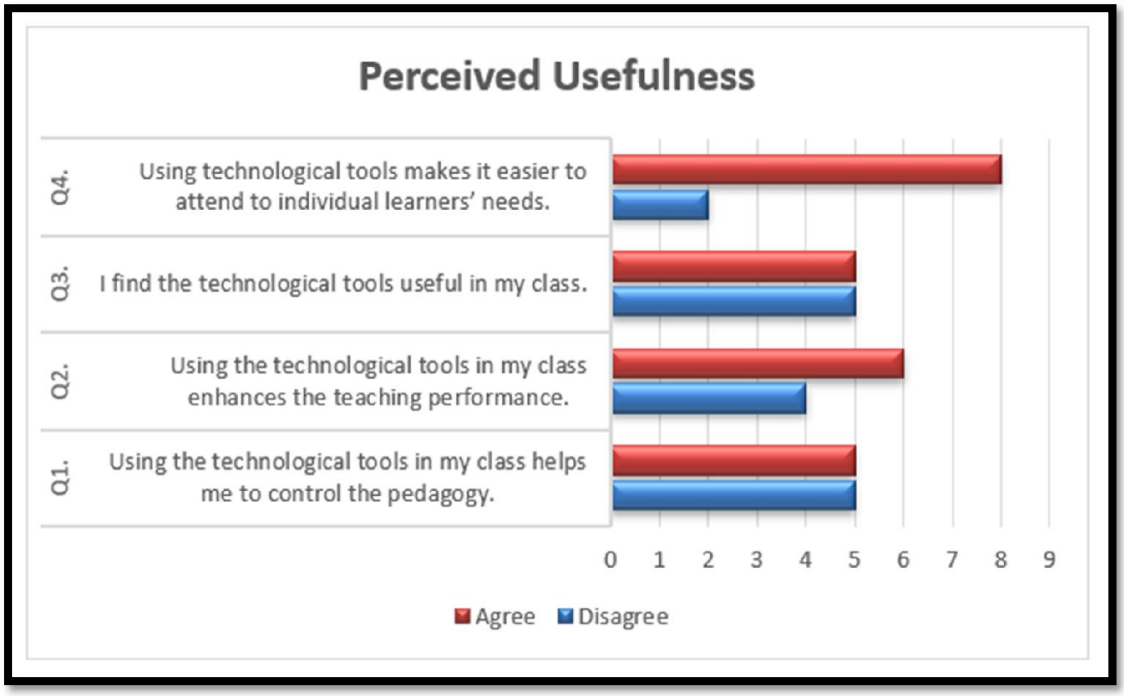


Figure 4.2.2: Perceived usefulness

Five questionnaire participants indicated that using technological resources assists in controlling the pedagogy (teaching methods). Additionally, six participants concurred that using technological tools enhances their teaching performance, where five stated that they find these tools useful in their teaching practices. Participant 6, during the interview session, said:

> *Technological tools are really fruitful for me, they are really helpful because, for example if you are teaching 3-Ds to a learner you end up getting some lines intersecting there but, in fact, they don't intersect at all. Maybe it's a hidden side from front view. So, learners mostly get confused mostly there unless you have the projector to show them what does a 3-D object looks like, moving it around so it's clear for me to teach that concept to show all sides and movement they can see practically as if they are moving around the house so that they can see that this corner is not in contact with that corner, so it is useful for me.*

Eight participants indicated that using technological tools when teaching mathematics makes it easy to give learners individual attention. The participants who shared this idea did not provide further details in this regard. Notably, these findings from the questionnaire were similar to some of the participant's responses from the interview session. The second interview question asked the participants whether they

find educational technologies useful for their teaching of mathematics. Participant 1 stated:

> *When using the Smartboard, you're able to just put up a worksheet on the board and have learners working on the problems while walking around assisting each and every individual learner that requires individual attention. It also saves time because I don't have to write the classwork activities on the board during the lesson like we used to when we were still using the chalkboard. Back then it was not easy to reach every individual in the classroom because you'd be busy wiping the chalkboard and writing…for this reason I find technology very useful for my teaching.*

Using technological tools in a manner that Participant 1 has stated can be debated as using technology as just another means of the representative media because in his case, he could have just printed the worksheet for all learners and still be able to give learners individual attention. When probed during the interview session, the participant stated that this is how he always utilise the technological tools in his classroom. Thus, it can be argued that Participant 1 did not utilise technology effectively to benefit from its various features and capabilities. Nevertheless, according to him, he finds his way of using technological tools useful.

In a similar way, Participant 2 said:

> *I've tried it minimally and I found that it was beneficial to learners because as soon as you put on the Smartboard in the classroom there is a shift in the way teaching is taking place in this very room and the learners get intrigued because they see videos, sound effect and so forth and these young kids are geared for, they're wired for technology so they immediately change their attitude in the classroom.*

Even though the participants were from different schools, being different individual cases, they shared the same sentiment about the usefulness of technology in the teaching of mathematics. Participant 6 stated:

> *I find them being very useful, because most of the time I prefer using technology because it goes straight to the point, it's useful to me because it attracts even the attention of learners, so they become more focused when using technological tools. There are some topics like 'space and shapes' that you cannot emphasise*

without these technological tools, which means if you do not have technological tools you are at a disadvantage, so they are really fruitful to me they are helpful…

Other participants who indicated that they do not make use of technological resources very often for different reasons stated that they believe these tools would be useful for their teaching of mathematics should they get enough support to use them. Even though some participants complained about not getting enough training, other participants had a different perspective on this. For instance, Participant 4 and 7 advanced that technological tools are easy to use where there is minimal training and self-training. Participant 7 further mentioned the importance of self-training as a complement to the provided training, and that the latter is not sufficient on its own. Participant 7 said:

Well, you know when I first started, it was eh…I won't say difficult, but you had to try and self-teach yourself because, you know there isn't much courses that you can go for, specifically related to maths…but then when you download the application and you start playing around with it, I mean, you learn a lot and it becomes easy as you use it more often.

In addition, on the perceived ease of use of technological tools, there was resonance between the results from the questionnaire, observation and the interview data sets. The results revealed that the participants who have used technological tools do not find them challenging to use. Figure 4.2.3 shows the summary of participants' responses based on the determinant of the perceived ease of use of the technological tools.

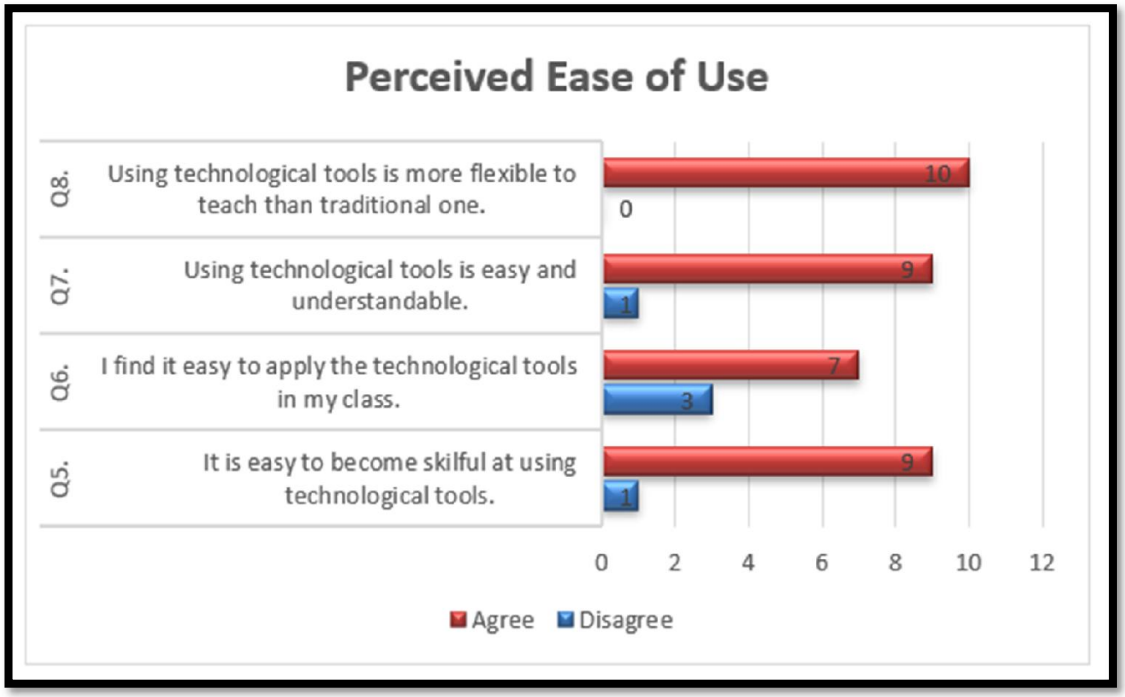


Figure 4.2.3: Perceived ease of use

Thus, nine participants, including the ones who outlined that they do not use technology in their teaching, indicated that it is easy to become skilful at using technological tools. Furthermore, seven of the questionnaire participants indicated that they find educational technologies easy to apply in their teaching, and nine participants in response to Q7 as shown on figure 4.2.3 specified that utilising these technologies is understandable and easy. At this stage of data collection, it was not clear as to why the participants perceived the use of technological tools as being easy while only six of them indicated that they were using it. However, at a later stage of data collection, it was established that some of the participants had various challenges that hinder them from using the available technological tools in their respective schools. Thus, one of the themes of this chapter discusses the challenges that the participants encounter in their attempt to integrate technology into their teaching of mathematics.

The questionnaire-based results concurred with what was observed during the lessons of some participants as they were deft in using their Smartboard technology. Participant 3 said:

> *Personally, it is easy to use, I have been exposed to the technological environment for quite a while now, for me it is easy, but the accessibility is another issue for our school currently*.

From the questionnaire-based data, six participants indicated that making use of technological tools makes teaching more flexible than traditional methods of teaching. Thus, during the interview session, Participant 1 affirmed that:

> *So recently I am more comfortable with the use of technology…in this Smartboard room whenever it's my period the learners come to me and I teach them using it. I remember at one stage our notebook licenses had expired; I would go back to chalkboard teaching. Then that's when I realised that hey! these Smartboards are actually user friendly and makes teaching easy and more flexible.*

Furthermore, Participant 8 maintained that:

> *No, it is easy to use, you just have to play around with it. Once you learn it you can't leave it and say I will come after three months and do it again because then you forget…but if you carry on using it, you find different ways and shortcuts to use it so that it can enhance your teaching…So, you have to be at it, you can't be trained all the time unless there's something new coming up, then you play around with it, you can't call somebody to train you…*

Nevertheless, not all the participants indicated that they find educational technologies easy to use (Participant 2, 9 and 10). When asked whether she finds the educational technologies easy to use, during the interview session, Participant 2 said:

> *No, because the training that was given to us by our sponsor was only a day and lasted for about an hour at my school. We also did not get a chance to interact with it on our own. We have tried interacting with it, but we are still very confused and unsure about it, especially when it comes to writing on the board and then saving a file and so forth. You know, we need at least follow up training sessions so that we become skilled in using it. If there were ongoing workshops, I promise you I would be using it more often…I tried putting it on now, but then I do not know how to collaborate the board you know, and how to do that and how to use different coloured pens, I am still a bit confused…*

With so much confusion and frustration, it shows that Participant 2 does not find the technological resources easy to use for her teaching. Regarding the ease of use, the participants had different responses to this question based on their unique experiences as they formed different cases. Moreover, from the participants' responses it was

established that the participants are still reliant on constant training, they do not want to take charge and train themselves.

4.3 CHALLENGES REGARDING THE USE OF TECHNOLOGY

The participants pointed out several challenges that they encounter in their attempt to integrate technological tools into their teaching of mathematics. This was due to the fact that each participant formed an individual case since they were from different schools. The participants were able to express the challenges they encounter during the interview sessions. Moreover, judging from their expressions, it appears like these participants had been waiting for such an opportunity to express their concerns regarding the use of technology when they teach. Their challenges ranged from the simple drawbacks which they have ultimate control over to barriers which are beyond their control.

For instance, Participant 3 was a special case because he had previous experience with technology from the school where he had taught before. However, he found himself in another school where the technological resources are locked up somewhere in the storeroom and could not be accessed by teachers as they please. Participant 3 said:

> *I am not using the laptop which has the Smartboard software, which will have a lot of activities because there is limited access to school resources and when we try to request for it there is always excuses. That's why we can't use it. We end up resorting to the chalkboard because of that…*

Figure 5.3.1 shows the inside of Participant 3's classroom which has the technological tools installed. According to the participant, the laptop which has the software for the board installed is kept in the principal's office.

Figure 4.3.1: Participant 3's classroom

Participant 1 on the other hand said:

> *The challenges I can think of quickly is the learners themselves, you know, once the learners see anything to do with the digital screen, especially when you download videos to show them, as soon as you show them a video of something educational they start saying "…hey Sir! Show us the movie…" to them if they see videos they think of music and all these things that are not educational. They'll be like "…now we have learned thisha (teacher), can we now watch this movie…". But, other than that, another challenge is that if there is something you are not familiar with, you must tell them beforehand that I don't remember how to do this let me try it, because if you try to hide that you do not know something they laugh and giggle and you can be ashamed and disturbed in your lesson. Besides that, and power failure, it is easy to integrate but you just have to be matured enough to say that 'ey' remember this is the new technology I am also learning as your teacher, then they accept and learn.*

Participant 1 further revealed that the reason why it was not easy to integrate at first, is because they received training at the wrong time in November just after the year end's final examinations and by the time he attempted to use it in February he had forgotten where to begin. He outlined that to overcome this challenge, he was assisted by a newly appointed teacher who was new in the field and had just graduated from

university. Figure 4.3.2 depicts the photograph of Participant 1's classroom. The photograph was taken before the observation session in his Smartboard room. As can been seen in figure 4.3.2, there is a whiteboard next to the Smartboard. Participant 1 stated that another challenge that they encounter at their school is that of power failure in the area. Thus, he uses the whiteboard for backup since the school does not have any other source of electricity.

Figure 4.3.2: Participant 1's classroom

In addition, participant 4 said:

> *I would say it's quite difficult to specify the challenge while I have not even attempted to use it…the material is there, it's a matter of knowing how to use it, which you'll simply say a challenge could be a lack of exposure which means I need training first. Yeah that's the only challenge because I wouldn't say the technology itself is a challenge, it is not…I am not deprived from using it, in fact I have to admit that I am the one who need to avail himself and seek assistance in terms of using it.*

During his lesson, Participant 4 was teaching a grade 9 class in a classroom which had a Smartboard system, but he only made use of the chalkboard that was mounted next to the Smartboard. Figure 4.3.3 depicts Participant 4's classroom setup.

Figure 4.3.3: Participant 4's classroom

In addition, Participant 2 who uses the whiteboard next to the Smartboard pointed out that:

> *You see, the programs depend largely on the Internet and Wi-Fi, now the sponsor had given us free Wi-Fi as you can see the router there (pointing to the router), because they had their own issues with budgeting for about two years now Wi-Fi has been stopped and then when that happened it means now we cannot even access the Internet because we need to do a lot, we use downloads, educational stuff from YouTube, and we can't.*

From Participant 2's response, it was evident that she does not take initiative to make use of the technological tools that were donated to them due to constraints related to Wi-Fi. She further stated that:

> *Then the software that they installed, like Yenka and another one called Smart notebook, needs constant updating and you can't update it if you do not have the Internet, so that has been a huge drawback. The second thing is training, we didn't have adequate training, we're expected to make a paradigm shift from chalk & talk to using Smartboards and smart pens etc. but one hour is not*

enough to help us with the transition. It should be ongoing, at least, let's say, monthly for about three months and at least have full day workshops until we get it…they should give us a break to come and try it, again have review workshops to ask us as teachers where we are experiencing problems, what the issues were and rectify them. It won't take long, if we can have like over a six months' period, I promise you, we would be fine.

Participant 8 on the other hand added that:

*The problem is with the safety of these resources…there is a high level of break-ins…that is sad because other than break-ins, we even had Wi-Fi, as you can see there (*pointing at the router*), so we were linked for everything and then the break in became a drawback and that is the biggest drawback to any technological advancement in any country…because we lost, not 30, but 46 computers, first time 25 were stolen, the next time another 21 were stolen. So, we're losing so much, that's companies that are giving this for free not the department of education, we got our ex-pupils who gave it to us and now we have an alarm system there, they bypassed the alarm system and still stole…so now if you look at this room we've got burglar guards inside, we've got burglar guards outside also, Jah that's the reason…safety is the important factor when it comes to technology. They go hand in hand because if you've got criminality at the same time they know that they can get money for technology, there is more money in technology than stealing this or that (*pointing at the textbooks and chalkboard*).*

Figure 4.3.4 is the photograph of Participant 8's classroom which was taken prior to the observation of a lesson that was conducted without the use of technology.

Figure 4.3.4: Participant 8's classroom

Figure 4.3.5 shows the area on the wall where the Smartboard and sound bar was removed by criminals (according to Participant 8). In figure 4.3.4, it can be seen that the projector was also removed, thus, leaving the classroom with only the chalkboard. Participant 8's school is located in the township area like the other 9 schools.

Figure 4.3.5: Participant 8's classroom

From the participants' responses it seems that there are several challenges that hinder them from integrating technology when teaching mathematics.

4.4 INTEGRATION OF TECHNOLOGY INTO MATHEMATICS TEACHING

This theme of the teacher's integration of technology emanated from the third research question that this study sought to answer. Thus, for the purpose of this study, the participant's responses alone were not adequate to respond to this research question. Hence, there was a need for document analysis of South African government policies and other documents which relates to classroom integration of technology by teachers. The issue of the integration of technology in South African schools has long been advocated by the Department of Basic Education (DBE). However, in all the ten schools where data was collected, there were no documents which contained the information about the integration of technology in the teaching of mathematics. The inference is that there are no circulars at the school level which advocate for the integration of technology for teaching and learning. Furthermore, the Senior Phase

(grades 7-9) and FET phase (grades 10-12) Curriculum and Assessment Policy Statement (CAPS) documents for mathematics has one comment mentioning the use of technology for teaching mathematics. That is "…draw a variety of graphs by hand/technology to display and interpret data…" (Department of Basic Education, 2011, p. 12). It was established that nothing was mentioned about the integration of technology in the documents that teachers (participants) use daily for their teaching. These include the textbooks they use, the Annual Teaching Plans (ATPs) and other circulars from the district level. Thus, it can be argued that teachers ought to be proactive in their respective teaching space to transform their methods of teaching.

However, the provincial and national government policies, guideline documents, news reports, magazines and reports on teaching and learning make mention of the use of ICT tools (technological tools) for teaching and learning. Table 4.4.1 presents the selected documents which were chosen for the purpose of this study as they specify the rationale for technology integration in teaching and learning.

Table 4.4.1: Documents analysed.

Selected documents	**Analysed data**
Document by Wilson-Strydom and Thomson (2005): The analysis of White Paper 2003	Conceptualising the integration of technology
Progress of the DBE with technology integration in Schools 2015	Strategies for effective technology integration in teaching
The South African status of ICT in education and the way forward 2016 NECT	ICT in support of teaching and learning
Analysis of Basic Education Report on the ICT Rollout February 2018	DBE initiatives taken over the years regarding the integration of technology in education
Annual Performance Plan 2018/2019	Operation Phakisa the ICT integration in education

The integration of technologies into the process of teaching and learning together with the general adoption of technologies in schools is reflected in the 2003 and 2004 White Papers as policy goals to be achieved (Department of Education, 2003; Department of Education, 2004).

This study conceptualises the integration and adoption of technology, following the publication of the 2003 White Paper. Wilson-Strydom and Thomson (2005) assert that "in practice, the adoption and integration of computers is a challenging and complex process for schools, particularly where there is limited previous experience in the use of ICTs to support teaching and learning" (p. 2). They further state that in the past, studies have shown that many South African schools who have been exposed to technologies, have mainly focused on 'learning about technology' instead of learning through or with the use of technologies. However, lately technology integration has been seen as utilising technology to learn, rather than learning about technology (Wilson-Strydom & Thomson, 2005). This implies that teachers are expected to use technology to teach rather than teaching about it.

4.4.1 Use of technology as static tools

To further understand the concept of technology integration, Wilson-Strydom and Thomson (2005) differentiate between the two forms of integration which are representational and generative use of technology, especially with the use of computers. The "representational use" which is mostly associated with the behaviourist theories, is about using technology (computers) to re-present information through an alternative medium (Wilson-Strydom & Thomson, 2005). Thus, here technology is not used to construct new knowledge. These scholars stated that utilising technology in this manner can be referred to as partly integrative. From the interview and questionnaire that was administered for this study, it can be argued that out of the six participants who indicated that they integrate technology into their teaching, five of them use it as a representational tool. During the interview session, participants were asked: "How do you integrate technology in your teaching of mathematics?"

In response to that question, Participant 3 said:

> *I mix it with traditional teaching, I don't use technology only during my lessons. The things that do not show clearly on the chalkboard or whiteboard I present them using technology…for example I'd take pictures or diagrams from the*

textbooks or question papers and project them so that learners would see clearly while we do the solutions on the whiteboard.

In a similar way, an observation session with Participant 7 was conducted in the first period after lunch. He took the researcher to the classroom, learners were already waiting for him outside the door, and they went inside after which he switched on the projector and the laptop. He then went to the whiteboard that was next to the Smartboard and did two examples of Probability problems on a grade 12 topic of the counting principles. Fifteen minutes later, he opened a worksheet from the laptop that he had connected to the projector and he displayed it on the Smartboard for learners to solve the problems as classwork. Thereafter he was moving around with a copy of a worksheet that was projected while he was marking and assisting learners. What stood out for the observer is that the participant only used the Smartboard to "represent" what he was holding in his hand. This was the representational use of technology. Thus, it can be concluded that he was using technology as a static tool.

In addition, Participant 8 said:

> *Yes! Even when I'm using my USB and showing them stuff that is happening presently, because they can see it and when I talk to them, then they can relate to the abstract, otherwise it is difficult for the child to relate to something that is abstract, when they see it happening then it makes sense to them…traditional teaching and teaching using technology goes hand in hand, you see I can show you that (*pointing the Smartboard*), but in order for me to explain the situation I need to go there (pointing at the chalkboard), that's why I have them next to each other, when I go there and write then I come back and show them again, then they say ey! That makes sense neh…because what you wrote there (*pointing at the chalkboard*) marries with this here (*pointing at the Smartboard*), so it makes more sense.*

Responses from the participants indicated that they mainly use the sophisticated technological tools as static tools instead of utilising them as dynamitic tools which can improve learners' visualisation skills in the learning of mathematics. Thus, it can be argued that the participants lack the knowledge of the tools they have at their disposal, thus underutilising them.

4.4.2 Use of technology as non-static tools

By contrast, Hokanson and Hooper (2000) argue that what is "…important about computer use is not being able to word process, or view a multimedia presentation, but the ability to interact with the computer in the manipulation and creation of knowledge through the rapid manipulation of various symbol systems" (p. 547).

Thus, the concept of generative use of technology pertains to using technology to generate knowledge. Wilson-Strydom and Thomson (2005) maintain that the "generative use" of technology seems to be underpinned by cognitive constructivist perspective of knowledge which implies that pedagogical practices of teachers are influenced by cognitive constructivist theories of learning. Thus, in this case, teachers are using technology as a cognitive tool which can be understood as completely integrative. Wilson-Strydom and Thomson (2005) assert that cognitive tools in this sense means that the role of technology during teaching is to enhance the cognitive powers of learners in the process of learning, thinking and problem solving. For this study, only Participants 5 and 6 appeared to be integrating technology as a cognitive tool in the classroom environment. From these two participants' interview responses, it can be argued that they utilise technology as a dynamic tool to enhance learner ability to visualise. Participant 6 said:

> *These tools are really fruitful to me, they are helpful because really for example, if you are teaching 3-Ds to a learner you end up getting some lines intersecting there but in fact they don't intersect at all, maybe it's a hidden side from front view so learners are getting confused mostly there so unless you have the projector to show them what does a 3-D object looks like moving it around so it's clear for me to teach that concept to show all sides and moving, they can see practically as if they are moving around the house so that they can see this corner is not in contact with that corner.*

According to the Department of Education [DoE] (2015), "the Department of Basic Education (DBE) was one of the first government departments to introduce public policy for integrating ICTs in teaching and learning" (p. 1). The goal of the policy (from the White Paper 7 of 2004) was that all administrators, teachers and learners in South African schools should be ICT capable (Department of Education, 2015). For teachers specifically, being ICT capable meant being able to teach ICT skills, teach using technological tools and show an improvement in obtaining each

subject's learning outcomes through the integration of technology. However, the policy did not specify as to how this goal was going to be achieved practically in a classroom environment for all schools in the country. Thus, the 2015 DBE's progress report revealed that "it is a matter of concern to the DBE that the goal has not been achieved" (Department of Education, 2015, p. 1). In addition, the policy goal and the DBE's reports and amendments do not particularly give clear direction on how teachers ought to integrate technological tools in their teaching nor does it recommend the model for integrating these technologies. Thus, during the interview sessions for this study, not even a single participant mentioned that there is a particular model of technology integration that underpins their use of technology during the teaching of mathematics.

The National Education Collaboration Trust (NECT) document by Meyer and Gent (2016) provides the status of ICT in South African education. It states that "progress should be measured against multiple criteria, and the focus should be on measuring the capacity of the system to integrate technology, and the capacity of teachers to incorporate technology into the process of teaching and learning" (Meyer & Gent, 2016, p. 33).

The NECT pathway for progress with the technology integration is clear. However, the implementation stage at the school level is not supported adequately as the participants of this study indicated in the questionnaire and interview responses that they do not get institutional support (from the department officials). They stated that it is mostly the private sector that offers them support to incorporate technology in their teaching. On the other hand, according to Meyer and Gent (2016), one of the DBE's strategies on technology integration is to provide teacher professional development (TPD) which is supposed to "be seen as a continuum from initial/pre-service training to continuous in-service training, and should be conceptualised as ongoing" (p. 7). This statement contradicts what the ten participants of this study from the ten schools indicated. In addition, one of the strategies for TPD outlined in the NECT document states that "an appropriate technology integration framework should include technology skill development and pedagogical use of technology" (Meyer and Gent, 2016, p. 8). Again, from the participant's responses, it can be argued that these are just mere blueprints which are not executed since the participants have no knowledge of such policies and frameworks for technology integration.

The South African parliament research unit conducted an analysis of basic education report on the ICT rollout which was authored by Madimetja Kekana and published on February 2018. The analysis reported that the government of South Africa went to Malaysia on a state visit where they were introduced to the "Big Fast Results Methodology" approach which focused on different forms of service delivery to the citizens. Kekana (2018) asserts that the South African government adopted the Malaysian approach and it was renamed Operation Phakisa which means "Operation Hurry up in Sesotho". Kekana (2018) further states that the operation initially prioritized the sectors of Health and Ocean Economy. However, because of its capabilities to accelerate policy implementation progress, the Basic Education Sector adopted the operation for ICT provision. In addition, the Department of Planning, Monitoring and Evaluation [DPME] (2017, p. 1) stipulates that:

> The monitoring of the Operation Phakisa ICT in Education is also conducted through reports by provinces to DBE. Provinces are expected to finalize their provincial Frameworks and provide monthly reports to the DBE by the 28th of every month. Thus far, most provinces have provided their ICT sector plans and aligned them with the Operation Phakisa Framework.

According to DPME (2017), this operation has achieved its goals in ensuring the provision of ICT in schools. DPME (2017) also maintains that the operation has five dedicated work streams which are: connectivity, devices, "teacher professional development, digital content development and distribution and e-administration" (p.1). Moreover, the Department of Basic Education (2019, p. 2) asserts that:

> The integration of e-innovation, e-governance and e-administration to enhance the use of ICT in teaching and learning will be the continued focus of our Operation Phakisa interventions, which are aimed at developing and modernising the skills of our teachers and learners to match the needs of the changing world.

Nevertheless, the ten participants who participated in this study indicated that they have never received any services of the Operation Phakisa in their district.

The participants' responses on how they integrate technology in their teaching of mathematics revealed that they were not adequately trained, as they stated that they were only 'shown' the basics of how to use the material they were sponsored with.

Those who are using technology stated that most of the things they know about the use of technology emanated from their own self-training. From their responses, it was apparent that their use of technology was not as advanced as teachers who have been using technology for a long period of time. Participant 1 who uses technology most of the time for his teaching than the other participants said:

> *I use Smartboard because Smartboard has got pages that you can write on save your lessons, although I've got whiteboard that I used before I no longer use it because with Smartboard if you want to use any page you can just click and change, you do not erase and if there is stuff you do not need on the page you hide or erase only that portion of the sum and then save wherever change is made…So for me I use Smartboard like an advanced chalkboard because of its sophisticated features which helps me improve my quality of teaching.*

The interviewer further asked Participant 1 if he only integrates technology when teaching specific topics in mathematics or if he uses it all the time. The participant responded by saying:

> *…any topic now, I integrate technology with any topic although in some topics it is easier to use than others. I use it like how other teachers use the chalkboard to teach on their everyday basis*.

Participant 6, who also integrates technology more often regardless of the challenges he encounters in the school shared that:

I use technology in conjunction with the traditional methods of teaching of chalkboard and chalk…for some lessons like Geometry I use technology most of the time to show diagrams clearly and for visualization purposes…even when I teach 3-D problems in Trigonometry I make use of 3-D viewer to enhance my learner's visualization skills, but with chalkboard it's hard for learners to visualise, very hard…like I said before if you are teaching 3-Ds to a learner you end up getting some lines intersecting there but in fact they don't intersect at all, so that's how I integrate it. If I see that a topic is not easy for learners to understand I even play them videos from YouTube and then I pause and explain because of language since most of the time videos from YouTube are done in English.

From the participants' responses on how they integrate technological tools during their teaching of mathematics, it can be argued that at this stage most teachers

cannot completely divorce the traditional methods of teaching regardless of the technological tools they may have at their disposal.

4.5 IMPACT OF TECHNOLOGY IN TEACHING MATHEMATICS

The purpose of this study was to explore the technology integration by mathematics teachers, thus, it was necessary for this study to enquire about the impact of technology in mathematics teaching. Hence, this subsection of the study presents the findings on the impact of integrating technology into mathematics teaching from teachers' perspective. The participants responded to the impact of technology based on their personal experience regarding the use of technology.

The participants were asked whether they have seen an improvement in learner performance or behaviour when taught using technology compared to when they were taught without it. Participant 1 said:

> *The performance is much better, I am saying it's better because not even with the results but also during the time when our license had expired learners were asking "Sir when are we going back to our Smartboard room" which means they were motivated and also they were more interested in it than in the traditional classroom environment, so they enjoyed it as well. Even on the results you could see that there is an improvement.*

He further stated that even when learners are given an activity displayed on the Smartboard, they do not make much noise because it is easy to control them when you are not on the board and you can engage with them easily.

Participant 7, in addition, brought a unique perspective about the impact of technology into mathematics. He stated that:

> *I'd say there has been an improvement. However, traditional methods of pen and paper are still very, very important because learners are still assisted by writing what they observe and knowing the skills. So, I don't think we can eliminate that traditional way of doing things in our classrooms. But yes! the performance has improved, as I said it just gives them a little bit better understanding of certain topics because they can visualise, they can see and they get a perspective from a different teacher in lessons on whatever it may be, so that definitely helps them to improve.*

Participant 5 had a similar response as Participant 7. They both see technology as a complement for traditional teaching not as something that can work independently for teaching and learning. He said:

> *Emh, I didn't go to the extent of comparing, I was just integrating it, I was not trying to assess it separately, comparing using technology and not using technology, so it's the complement to traditional teaching, it's just integrated like that…but I can just speak with regards to the fascination of the kids, like for example, once you just take a projector, there is a fascination that kids will have, their attention, you know everybody is glued to the screen looking forward to this amazing lesson that you have. So, it sorts of motivates them to want to learn and when they are motivated to learn they produce good results at the end.*

Furthermore, Participant 6 on the other hand had a unique but related response regarding the impact of using technology in his teaching of mathematics. He shared that:

> *Unfortunately, I never teach those sections using traditional teaching, I never teach those topics without technology. Previously at the school that I was teaching in before coming here, I used to teach them in the old way, the traditional way. So, they used to learn but slowly, as I have said earlier that it is even harder to teach 3-D shapes or teaching about 3-D objects when using traditional ways, so I saw that they were struggling, I didn't have time to see what positive change would bring to use technological tools, I only made sure that I use it totally here in this school when I realised that those learners were not slow naturally but they found it difficult to differentiate, to make meaningful sense of the concept. I think looking back to that school I said they were slow in understanding the concept, now I never find a problem of getting many questions asking about the same concept that I have taught using technology, so it means that technology makes sure that learners understand. I believe that it works, I don't know, maybe I must stop using it once and then use it later to compare. But anyway, I think it's better using it, there are less questions and they understand at once which then has a positive impact in their performance on this topic and others.*

The impact of technology from this study was understood from teachers' experiences of teaching with the use of technology. Other participants that were interviewed stated

that there are challenges that prevent them from making use of technology in their teaching. However, those participants as well believed that technology could have a positive impact in their teaching of mathematics. Participant 9, for instance, said:

> *Since I have not started to make use of the technology we have here in our school and have not used it before in my teaching, I can't say I have seen an impact of it in my own teaching of mathematics. But I believe that it could make my teaching easier and the subject less challenging for my learners…a different kind of teaching that involves the use of technology for this generation of learners would definitely change their attitude towards the subject and probably improve their performance as well. So, jah the integration of technology would have a positive impact on my teaching.*

Similarly, Participant 10 had the same belief as participant 9 regarding the use of technology when teaching mathematics. However, this participant stated that:

> *I have attempted to integrate these technologies; tablets and Smartboards for a very short period of time before…but I stopped using them before realising their impact on my teaching because I had problems with a high volume of learners in this technology equipped classroom and I was not well clued-up regarding the use of these resources. So, if I didn't have these two challenges, I believe technology would have had useful impact on my teaching because learners were intrigued when I brought them here a few times for some lessons.*

During the observation session in participant's 10 classroom, the observer was standing right at the back of the classroom because learners were packed in threes per desk with very small space to move in between the desks. Participant 10 stated that the problem with overloaded classrooms in their school limit them in terms of flexible teaching, thus they stick with traditional teaching of chalk and talk.

In as much as this study did not mainly focus on investigating the impact of technology in teaching mathematics. The participants from their limited experience of using technology in their teaching of mathematics indicated that there is a glimpse of a positive impact from utilising technological tools for teaching mathematics.

4.6 ATTITUDE TOWARDS USING TECHNOLOGY

From the questionnaire, observation and interview data sets, participants' attitudes towards the use of technology were assessed directly and indirectly. The questionnaire responses indicated that almost all the participants, including the ones who are not using technology for their teaching, had a positive attitude towards the use of technology in their teaching. Figure 4.6.1 depicts the summary of participants' responses regarding their attitude towards using technology in teaching mathematics.

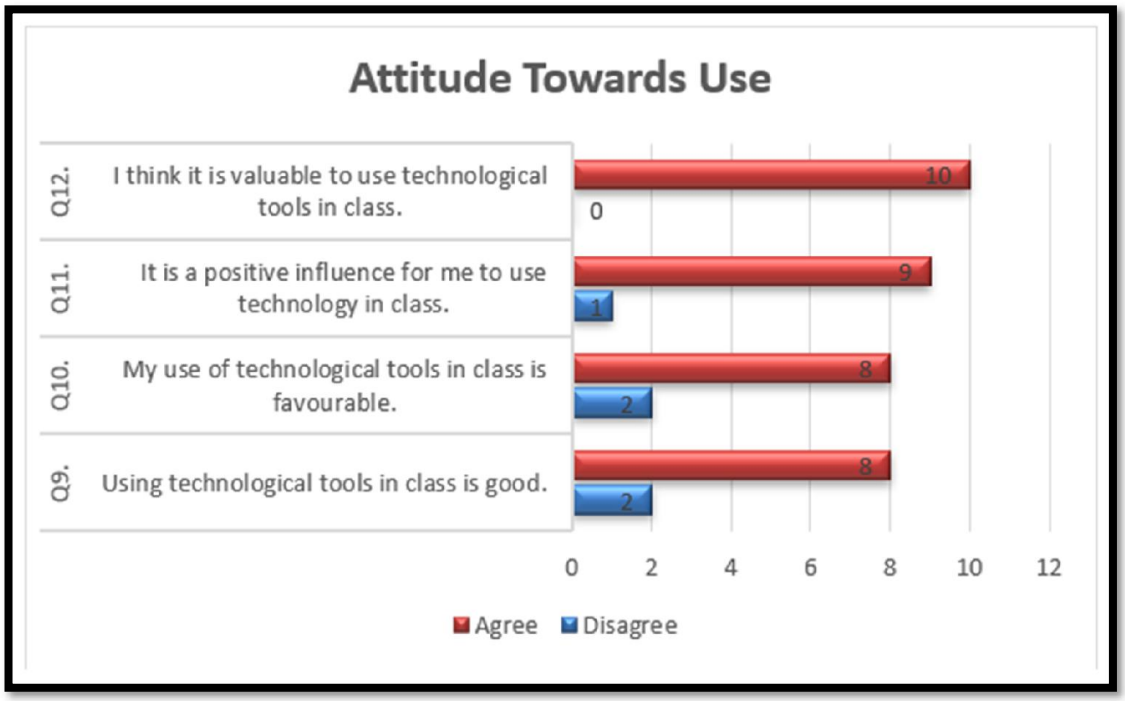


Figure 4.6.1: Attitude towards use

The participants' responses in this category may seem slightly inconsistent with their responses from the other three categories of 'external factors'; 'perceived usefulness' and 'perceived ease of use'. This is because the participants at this stage were responding as if they were all using their technological tools for teaching. For instance, eight of the ten participants indicated that using technology in their classroom is good. However, there were six participants who indicated that they use technology for their teaching of mathematics, thus the additional two here in Q9 were the participants who stated that they believe using technology would be good for their teaching. Likewise, eight of the ten participants in Q10 stated that their use of technological tools in class is favourable and only two disagreed with this statement. Additionally, nine participants in Q11 indicated that using technology has a positive

influence on them in the classroom. Three of these nine participants are those who believe that using technology in their class would have a positive influence. Lastly, on the category of attitude towards using technology, all the ten participants believed that it is valuable to utilise technological tools in the classroom.

In addition, the last question of the interview asked the participants whether they would recommend the technological resources available at their schools to other teachers. This question was asked to gain an insight of how the participants feel about the use of technological resources in the teaching of mathematics. Participant 1 said:

> *Definitely, I mean we've only got two Smartboards now in our school, every classroom should have one and other schools as well I am still surprised, although it is new to us, to find that there are schools who do not even have one single Smartboard in their school. Especially for teaching other subject like Natural Science (NS) let alone maths, in NS there is more, if you do not have a laboratory you have a Smartboard to show learners things that you need, like experiments*.

Participant 1 further outlined that he does not only use his technologies to teach mathematics, he also integrates technology when teaching other science subjects because of the capabilities of the type of technology he uses. In a similar way, Participant 2 who indicated that her challenges deprived her from using technology in her teaching, stated:

> *I would highly recommend it because I know about the benefits, and if teachers are highly skilled at it like Model C schools, I know what they can do with it. So, I am aware of how amazing it can be in the classroom and how it can transform teaching in the maths classroom, but I need to be trained to use it. It also requires a lot of preplanning on my part because I would have to search the Internet because there is a lot of material out there, so I would have to search YouTube to try and download stuff, that's one 'videos' then there would be lots of past year papers etc. Now in order to access that, there is a lot of websites with these materials, but I need the internet. And our school is very under resourced, I think the problem is with the low school fees, I mean we, ourselves, do not have a telephone. We have the principal who pays for internet usage and there is a very limited amount of data that they get which is for admin purposes. So, these are all the challenges we face that are preventing us from making effective use of the*

Smartboards. I am very willing to learn because I realize technology is the answer to any of our education problems, and you can't have learners learning in the classroom where there is a chalkboard, and that very same learner leaves at grade 12 and goes into university, is expected to be part of the Information age and part of the technology race they are calling the 4th industrial revolution because for 12 years of their lives they have been exposed to the most basic learning tools. So how nice would it be if they were exposed to it in the classroom.

The interviewer could tell from Participant 2's facial expression that she meant what she was saying and she was desperate about being able to integrate technology in her teaching of mathematics and to influence other teachers to do the same. Her response showed that she possesses high behavioural intention to make use of technological tools at her disposal. In addition, Participant 4, who also stated that he has not started to make use of technology in his teaching as yet, said:

Jah, Jah, I would definitely recommend it because for me I believe it will make things easier, particularly moving from the old traditional way of doing things. You can find almost everything there in these technologies, the questions, the demo, the practical, everything! It is in there, it's a matter of knowing how to use it. So, if most of the schools can have such technologies, not just for the sake of having them but be able to use them effectively, learners might be inspired because at times we can talk of, for example a kidney, learners cannot even visualise where it is located and how it looks like, that might be a challenge. But with this technology they've got everything, so I believe schools should try to get started using it and those that don't have it as yet to find a way to, at least, seek for sponsorships and get these technological tools.

Participant 8 was emotional in his response to the last question of the interview. It was apparent to the interviewer that if it were possible for him all teachers would be using technology for their teaching altogether. He said:

Yes! Yes, I'd recommend it to all the schools, but in order to recommend it, I'd first recommend that teachers go for training, they need to go for basic training and the teachers need to be told that they must use it from the time when they go back. They can't go back, put it in the cardboard and take out when they want it after 3 months they forget it…then you can't be training teachers every year,

that's a lot of money being spent and wasted…once you do it and the teacher carries on using it then you find that it becomes easier…You know, like teaching someone to do your grid, put the grid on the computer, you show them this is how you do your grid, this is how you show your lines and so forth, you got the grid? 'Yes, I understand' you go…then the whole year goes by when year-end comes then they say 'okay fine I've got my computer here just show me again, you showed me in January, I forgot' but you didn't use it! That's your fault! Now that's the problem.

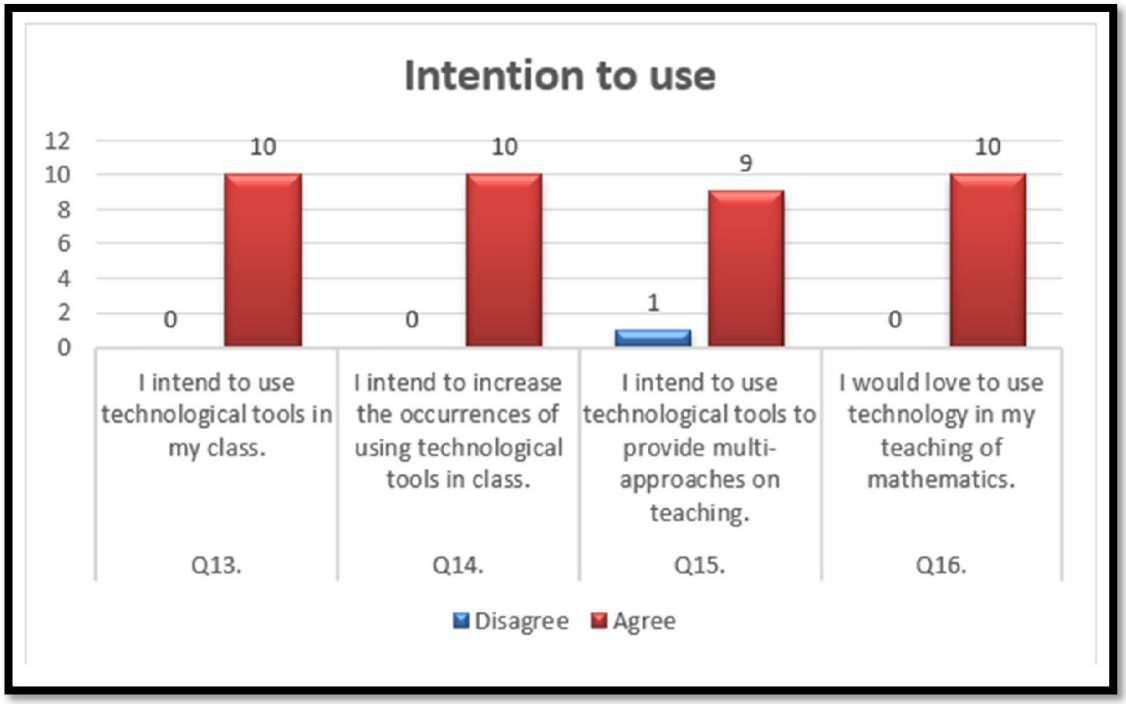
This participant demonstrated a high positive attitude towards the use of technology in the field of mathematics teaching, and he was so frustrated by teachers who underutilise technological resources once they have them available. Moreover, Participant 6 outlined that:

Yes of course, in fact I would say let's get rid of the traditional way and use technology, so technology for me is easy, it's easy to use, it makes it easy to switch from a certain page to another page unlike the chalkboard…with technology you just say create a new sheet or just undo this if you want to use the same sheet, so it's quite easy to use technology. Because I was thinking of that, how about teaching with the technology throughout the subject and I realised that it's possible for all subjects, because even if you have to teach or you have to let learners read the book, you can display it using a projector and scroll down, you can use your coloured pens there, you can highlight where they must take notes and tell them start here and end here. For every subject I think it would be better and the curriculum would be moving fast, you can finish early using that because you would save a lot of time. I think for every teacher it would be fruitful, more especially in maths. Sometimes in maths we have to use a graph, not to teach how to draw the graph but to study the behaviour of the graph. So, you have to make sure you plot all your axes accurately and when you use technology you can just use the graphing software then they'll see it within a second and you can simply highlight with different colours without having to look for chalk and sketching the graph on the chalkboard. I'm only just making a typical example with graphs, but there are many things you can do with the kind technology we have to enhance the teaching of mathematics.

The participants' responses regarding the attitude towards using technology in the classroom indicates that it is the "external factors" as well as other additional challenges that hinder them from making use of educational technologies. Otherwise, their responses revealed that they were positive about the integration of technology towards the teaching of mathematics.

4.7 INTENTION TO USE

Using the questionnaire data set, participants' behavioural intention to make use of technological tools for mathematics teaching was briefly interrogated. Figure 4.7.1



graphically represents a summary of participants' responses regarding their intention to make use of technological tools.

Figure 4.7.1: Intention to use

For instance, all the ten participants for Q13 indicated that they intend to make use of technological tools in their classroom and they further outlined in Q14 of the questionnaire that they intended to increase the occurrences of using these tools. Additionally, nine of the ten participants who participated in the study indicated that they intended to use technological tools to provide multi-approaches to teaching. This, concurred with what some of the participants indicated during the discussion after they completed the questionnaire, that technology offers them different approaches to their

teaching of mathematics. Moreover, all the ten participants outlined that they would love to use technological tools in their mathematics teaching. The results indicated positive behavioural intention to integrate technological tools into mathematics teaching at the school level.

4.8 SUMMARY

From the results of the study, it can be concluded that mathematics teachers from the ten schools where data was gathered liked the 'idea' of technology integration into the teaching of mathematics. Nonetheless, during the data collection stage at the research field, it was established that not all the teachers who have technological tools at their disposal use them. Thus, it seems technological tools at schools are underutilised. The findings further revealed that mathematics teachers are still fixated on the use of traditional teaching of 'chalk and talk' even with the presence of sophisticated technological tools at their disposal.

Furthermore, the findings revealed that the South African DBE encourages and takes initiatives in promoting the integration of technology in teaching and learning. However, the results showed that the DBE's initiatives and support are inadequate because they fail to reach all the districts in the provinces.

The results indicated that the lack of training and support has a negative impact on teachers' motivation to make use of educational technologies. However, for some participants, this does not affect their behavioural intention to use the technology at their disposal.

4.9 CONCLUSION

The extent of technology integration in the teaching process in schools is influenced by many factors which ought to be dealt with from all levels of the South African Department of Education (DoE). This chapter presented the findings of the study according to themes which emerged from the data. The next chapter is going to focus on the discussion of results in relation to the main research questions and the literature that was reviewed for this study.

Chapter 5: Discussion of the findings, Conclusions, Limitations and Recommendations

5.1 INTRODUCTION

The concept of technology integration in the process of teaching and learning at the school level might seem relatively straightforward from the government policies and other official documents promoting this integration. However, the actual implementation is far more complex as there are many contextual factors that affect the actual integration of technology in the classroom. This was corroborated by the findings of this study which demonstrated that there were various challenges that occur at the school level regarding the actual integration of the technological tools in the teaching of mathematics. Additionally, based on the results from the literature that was reviewed for the purpose of this study, it was established that technology integration during instruction is influenced by several different contextual factors.

The previous chapter presented and analysed the findings of this study. This chapter offers a discussion of the main research findings in the light of the research questions and links the research outcomes to the literature and theory, where applicable. Furthermore, conclusions, limitations and recommendations based on this study are presented in the chapter.

5.2 DISCUSSION

5.2.1 Teacher experiences towards the integration of technology in mathematics teaching

The first research objective of this study sought to investigate the experiences of teachers regarding their integration of technological tools in mathematics teaching. Several conclusions which pertain to this objective can be drawn from the previous chapter. Even though the findings of this study were gathered from a relatively small group of participants, the results are expected to provide a meaningful insight since this is a qualitative enquiry.

The findings from the analysis of data revealed that teachers possess varying experiences regarding the integration of technology in mathematics teaching. The findings revealed that teachers with more than ten years of teaching experience obtained their qualifications when technology integration was not as popular as it is in this century. Thus, their experience regarding the use of technological tools in the teaching of mathematics was observed to be scant. Nevertheless, this issue, according to the findings, did not impact on participants' use of technology when they had it available at their schools. On the other hand, the findings revealed that teachers with less than ten years of teaching experience were exposed to the use of technology during their pre-service training. However, the results further revealed that there are other different factors that influence the utilisation of technology by teachers. These results are consistent with what was stated by Saleh and Drew (2014) while describing the variables of the TAM framework which underpins this study. This coincides with what was earlier stated by Davis (1989) who asserts that there are many variables which influence people's decisions to either accept or reject new technologies in their working environment. Thus, for this study, participants' responses indicated that it was mainly external factors that influenced their acceptance of technological tools into their mathematics teaching. For instance, all the ten schools where data was collected have two classrooms each which are fully equipped with technological tools. However, from the findings of the study, some participants indicated that they cannot make use of the available technology because the classrooms with these technological tools cannot contain the number of learners they teach per grade. Thus, this gave them reasons not to accept technological tools for their teaching. The issue of overcrowded classrooms in some South African township high schools is confirmed by literature (Naude & Meier, 2019; Rammala, 2009).

Furthermore, among other factors that influenced participant's decisions to accept and use technological tools in their teaching is that of support and training. From the results of the study, it was established that most participants were more reliant on the extensive training and as a result some participants stated that they do not integrate technology in their mathematics teaching because they were not adequately trained. Literature from numerous research studies (Najdabbasi & Pedaste, 2014; Stols et al., 2015; Ghavifekr, Kunjappan & Ramasamy, 2016; Saal, 2017; Ojo & Adu, 2018) has also shown that teachers refrain from making use of technological

tools in their teaching due to lack of training, skills and knowledge to effectively integrate technology during instruction. Thus, the results from this study appeared to concur with the findings from several studies aforementioned.

On the contrary, other participants from this study maintained that they self-trained themselves in order to become better at using the technological tools they have at their disposal. Again, this coincides with the findings of the study conducted by Amuko, Miheso and Ndeuthi (2015), which revealed that some teachers train themselves on how to integrate technological tools for teaching. Furthermore, those participants who trained themselves to integrate technological tools into their teaching outlined that they perceived the integration of these tools as being ease in their mathematics teaching. These findings correspond with Davis' (1989) argument that, the degree at which an end-user is convinced that making use of technological tool would be effortless, is regarded as an underlying factor for perceived ease of use. Thus, the results revealed that these participants who perceived technology as being easy to use, accepted and strived to integrate it in their teaching environment. With that being the case, the results showed that the behavioural intention to use technological tools had an impact on the ease of use that the participants from their respective schools demonstrated. Hence, it can be concluded that behavioural intention to use technology motivated teachers to train themselves. These findings relate to what Matikiti (2018) and Ajibade (2018) alluded to in their attempt to unpack the concept of behavioural intension to use determinant of the TAM framework.

From the teachers' experiences, the findings demonstrated that at times teachers lack time to make use of the available technological tools for their teaching. According to Saleh and Drew (2014), this can be understood as one of the internal factors. The potential users of technological tools have utmost control over these factors, and they are further influenced by the attitude that users possess over the use of these tools. These results of the study regarding the lack of time to use technology in teaching are exhibited in Ghavifekr and Rosdy' (2015) findings on the integration of technology in the process of teaching and learning. Ghavifekr and Rosdy (2015) contend that "teaching time is not enough for teachers to use the ICT for teaching and learning purposes" (p. 184).

In addition, the results demonstrated that once the teachers have found the technological tools easy to use and have actually used these tools, they then perceive

them as being useful in their teaching. These results concur with Stol's (2007) argument on the determinant of perceived usefulness of technological tools. However, further from the findings of this study, the results revealed that even those participants who did not make use of the technology at their disposal, believed that their tools would be useful in the teaching of mathematics. Thus, it can be argued that these participants merely believed that the use of technological tools in the process of teaching mathematics has the potential to improve their teaching performance. However, due to challenges to be discussed next, these participants could not make use of technology in their teaching.

It was further established from the findings that the teaching experience, age and teacher qualification does not affect the teachers' usage of technological tools during the process of teaching. Therefore, teachers decide to make use of technological tools based on numerous contextual factors discussed in this chapter.

5.2.2 Challenges encountered by mathematics teachers in their attempt to integrate technology

From the study findings, there were dissimilarities and commonalities between the participants' cases regarding the objective of the challenges encountered by the mathematics teachers in the attempt to integrate technology. This objective assisted the study to understand the underlying factors contributing to the non-use or less effective use of technological tools by teachers in mathematics teaching.

Among other challenges discussed in the study's findings was that of limited access to the technological tools by teachers. This challenge was from one of the ten cases that were being explored in this study. The reviewed literature for this study revealed nothing of this type of challenge that teachers encounter in their attempt to make use of available technology in South Africa. Nonetheless, a study that was conducted in Malaysia verifies the findings of this as it revealed that "sometimes, ICT facilities are completely provided but little access to ICT prevents teachers from using it in teaching" (Ghavifekr & Rosdy, 2015, p. 184). From the results of the present study, it was established that the senior members of the school strive to protect the technological tools that the private companies donated to them so that they can keep on giving them more. However, in their attempt to keep these tools safe and protected they end up depriving the teachers the opportunity that is afforded them to transform their teaching.

In addition, from the findings of the study, it was established that there was a high rate of theft among the schools in some of the township areas where data was collected. These findings concurred with the study by Pernegger and Godehart (2007) which described the South African context of township schools. The results revealed that there must be high security systems in place in South African township schools with any form of technological tools because of crime in township areas. Thus, it can be argued that when schools around certain township areas attempt to install technological tools, they must have sufficient budget for adequate security. However, as was outlined in the literature, the schools from township areas are characterised by poverty with low standard of living among other things (Pernegger & Godehart, 2007; Rammala 2009; Naude & Meier, 2019). Thus, obtaining high security systems in these schools would be another challenge. The issues of crime in schools where data was collected for this study was one of the major challenges that deprived teachers of the opportunity to try and adopt technology into their teaching environment. This is again another external factor, according to the TAM framework, that contributes to teachers not making use of technological resources in their schools. Nonetheless, from the literature, there was minimal evidence of the cases of theft in schools which hinders the implementation of technology.

According to the results of this study, another challenge that was common among the schools where the study was conducted is that of electric power failure. The findings revealed that this was the major challenge since all the ten schools where data was collected could not afford any other source of power to cater for technological tools which are power dependent. This challenge with electricity in some of the parts of South Africa is not new. Laaria (2013b) and Mukhari (2016) found that electricity is one of the challenges that disrupt the implementation of technology in schools located in poor environments in South Africa. Thus, without power, teachers cannot make use of technological tools for their teaching. Therefore, it was found in this study that teachers become demotivated to plan their lessons for technology integration because of the unforeseen disruptions. The findings further established that in order to deal with this challenge teachers revert to traditional teaching as they have no other feasible solution.

Furthermore, another issue that was common from the results of the study was that of the lack of training, skills and knowledge of how to integrate technological tools

for teaching. The findings revealed that teachers were only given a once off one-hour training on how to use the technological tools that were donated to their schools. The results showed that some of the teachers were not confident enough to use these tools during their teaching, thus, they found every excuse not to use them. The challenge with training, skills and knowledge on how to integrate technology during the teaching process is common among other research studies that have been conducted regarding technology integration (Mashile, 2016; Najdabbasi & Pedaste, 2014; Padayachee, 2017; Yuen and Hew, 2018; Zhao, 2003). On the other hand, it was established from the findings that some teachers can train themselves on how to integrate technological tools in their teaching of mathematics. Nevertheless, the results further revealed that those participants who trained themselves were not using their technological tools effectively in mathematics teaching. These results concur with the findings from other research studies which advocate that some teachers can use technological tools during instruction, however, because of the lack of TPCK, they fail to integrate these tools effectively. Numerous researchers (Bingimlas, 2018; Mishra & Koehler, 2006; Niess, 2005; Tondeur et al., 2017) regarding the integration of technology in teaching have argued that TPCK also known as TPACK is very imperative when teachers attempt to effectively integrate technology in their teaching. The findings of this study further demonstrated that most teachers lack on TPCK. Thus, it can be argued that when teachers lack on TPCK, they are less likely to effectively integrate technological tools in their teaching. To deal with this challenge, the findings showed that the participants wait for the support from the department.

5.2.3 The extent to how mathematics teachers integrate available technology

It is important to note that this theme emanated from the document analysis and semi-structured interviews data sets. It was found that there are few official government documents that are easily accessible to teachers at the school level with guidelines on the use of technology in the teaching of mathematics. However, at the provincial and national level, documents relating to the integration of technology in teaching and learning were found. The results revealed that there are government policies which advocate for the integration of technological tools in the process of teaching and learning. However, what was established from the findings is that these policies as well as the analysis of these policies do not necessarily specify how teachers are supposed to integrate technology into their teaching. For instance, from the

literature that was conducted for this study, it was established that there are different models of technology integration that teachers ought to align their integration with (Çelik, 2011; Kimmons, 2016; Mishra & Koehler, 2006; Surry, Robinson, & Marcinkiewics, 2001). Nevertheless, the present study revealed that teachers are not aware of any model of integration. Moreover, the official documents from the DoE are also silent regarding the "how" of technology integration in teaching, thus, they suggest no models for teachers.

In addition, the findings revealed that since some of the participants stated that they do not make use of the technological tools at their disposal, the study could not acquire data from the entire sample. However, the results obtained from 60% of the participants afforded the study to respond to the third research question. Consequently, the findings revealed that most teachers who indicated that they use technological tools for their teaching used these tools as static tools. They mainly utilised the technological tools for representational use. It can be argued that technological tool like Smartboard used in this manner was underutilised because this type of technology possesses high capabilities of being interactive and dynamic. Thus, the findings pointed out that two-thirds of the participants who indicated that they use technological tools for mathematics teaching, did not use these tools to enhance learners' ability to visualise, for example. For them, it was merely for projecting contents which they could have easily printed and given copies to learners.

Nevertheless, it is worth noting that the study participants demonstrated a lack on skills and knowledge as was discussed in the previous theme. Thus, it was realised that mathematics teachers who participated in this study lacked on TPCK, consequently underutilising the technological tools. It can be argued from the results that one of the main reasons for this underutilisation was the lack of support that teachers receive, since they are also not active in learning about technology integration on their own.

5.2.4 Impact of technology integration in mathematics teaching

This theme on the impact of technology integration in mathematics teaching emanated as this study was attempting to respond to the fourth research question. It was anticipated that the participants of this study would provide enough data to properly respond to the last research question. However, the findings revealed that more than half of the participants in this study did not make use of the technological

tools for their teaching of mathematics because of the reasons discussed in the previous themes. Over and above, the results revealed that those participants who stated that they use these tools did not use them effectively in their teaching of mathematics. Thus, it was not easy to attain comprehensive teachers' perspectives on the contribution that technology has in mathematics teaching.

Nevertheless, the findings revealed that six teachers (participants) observed the positive attitude from learners towards the learning of mathematics when taught using technology. In addition, it was established that the use of technological tools when teaching mathematics has the potential to enhance learners' experiences of learning mathematics. It must be noted that this theme emanated from the interview data set. However, the scant findings on this theme concurred with the results of numerous research studies (De Vita, Vershaffel, & Elen, 2014; Janier, Shafie & Ahmad, 2012; Willacy & Calder, 2017) that have attempted to investigate the impact of technology integration in the process of teaching and learning. The contribution of technology to mathematics teaching from the participants' perspective is limited to positive attitude that learners demonstrate to the learning of mathematics as compared to when they are taught using traditional methods. The underutilisation and ineffective use of technological tools by teachers who participated in this study resulted in them being unable to outline the contribution that technology has on their mathematics teaching. The least they could state is that teaching using technological tools assists in making learners visualise 3D geometric shapes.

The findings of the study further revealed a positive attitude among teachers towards the use of technological tools in mathematics teaching, even though they did not use it optimally and effectively due to different challenges. Teachers' (participants') positive attitude towards using technology was deduced from the findings when they advocated that other teachers in other schools ought to have the technological tools they have in their schools. Thus, it can be argued from the findings of the study that the external and internal factors affect the teachers' integration of technology in mathematics teaching. The internal factors that impact on teachers' use of technology include the cases of teachers who are indolent to adapt to the 21st century digital world. Thus, it can be argued that there is some form of comprehensive intervention that ought to be done in order for teachers at school to be afoot with the expectations of the digital world.

5.3 CONCLUSIONS

This chapter concludes an exploration of the integration of technology by selected teachers when teaching mathematics in the province of KwaZulu-Natal. This study sought to explore the integration of available technological tools by teachers in the teaching of mathematics. The study revealed that the technological tools are underutilised in mathematics teaching. It was further discovered that there are several factors which contribute to this underutilisation, namely:

- The lack of adequate training for teachers to effectively integrate technological tools in the process of teaching and learning;
- Lack of access to policies and guidelines regarding the integration of technological tools in the classroom environment; and
- The issue of theft in township areas disrupting the implementation of technological tools schools.

The combination of external and internal factors has been identified as a major challenge that impacts on user motivation to make use of technological tools in the teaching process. This further impacts on the actual use of technological tools. Thus, according to this study, it does not matter whether users find the use of technology easy or useful for their work, the external and internal factors determine whether users (teachers) will make use of the tool.

5.4 LIMITATIONS

One of the limitations of this study is that the questionnaire consisted only of close-ended questions and during the data analysis phase of the study, some responses needed more clarity as they were not explained. A more adequate technique would have been to ask each participant to justify his or her response after making a choice on whether he or she agrees or disagrees with each item on the questionnaire.

Another limitation of this study is that the researcher was again supposed to ask each participant whether s/he uses technology available at his or her school for their teaching of mathematics prior to collecting data. This is because it was realised that participants could not respond properly to some questions on the questionnaire and to interview questions due to their irrelevance for them because they indicated that they do not use any technological tool in their teaching.

In addition, to gain more insight into the problem statement of this study, it would have been better to get learners' perspectives on how they find the learning of mathematics when taught using technological tools.

5.5 RECOMMENDATIONS

In this century, it would be cumbersome to start training novice and in-service teachers to integrate technological tools into their teaching. Rather, pre-service teachers ought to be equipped with at least TPCK together with models of technology integration in order for them to know what to do when they are presented with technological tools for teaching. For instance, the European commission (2019) outlines that in most European countries, teacher training institutions prepare pre-service teachers to be digitally competent and able to strategically integrate technological tools with confidence. South Africa as a developing country ought to adopt such strategies at basic education even though there is still a lack of infrastructure in basic education.

For future research, this study suggests an exploration of teachers' perceptions on the use of technology in mathematics teaching. Having an insight on mathematics teachers' perceptions in this regard would assist in understanding whether mathematics teachers are better-off without technological tools or if they require skills for using them.

Another research that could be conducted would be to try and investigate the relationship between teachers' exposure to policy guidelines regarding technology integration and the use of technology in classroom teaching. In addition, exploring pre-service mathematics teachers' skills and knowledge regarding the integration of technology in mathematics teaching would be interesting for future research.

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Appendices

APPENDIX A: PRINCIPAL CONSENT LETTER AND DECLARATION

Informed Consent Letter to School Principal

Dear Principal

Ms/Mrs/Mr/Dr…….

Name of school ……..…..

Re: Permission to conduct a research study in your school

I am writing to request your permission to conduct a research study in your school. This research study is entitled:

An exploration of the integration of technology into mathematics teaching: The Case of 10 Schools in KwaZulu-Natal in the Umlazi District.

My name is Mzwandile Zulu and I am currently studying towards a Master's Degree at the University of KwaZulu-Natal (UKZN). As part of the requirements of this degree, I am required to complete a research thesis. This study focuses on exploring the integration of educational technologies by mathematics teachers.

I require two mathematics educators of any gender or age, teaching any grade to participate in this research. I would be very grateful if you would consent to these educators participating in this study. They will be selected from your school.

If you agree to this, they will be invited to respond to a short questionnaire, be observed in the Smartboard classroom and be interviewed in pairs.

All discussions, interviews and dialogues with participants will be audio recorded using a dictaphone, and thereafter transcribed verbatim to produce transcriptions. This research information (data) is required for the analysis of data and completion of the actual write up of the thesis. Collecting research information for this study will take approximately 30 minutes with both participants. The process of data collection, that is: response to the questionnaire and interview will take place in your school premises, with your permission. Times and dates will be discussed and arranged with you and the participants at a later stage. I will try to ensure that this takes place during their lunch breaks and free periods, in an attempt to avoid any disruptions during lessons. Participants will also be encouraged to eat their lunch during discussions and interviews, as well as make use of the school toilet should the need arise. I will not deprive them of these opportunities, especially since I intend to use some of their free time in order to collect sufficient data for my study.

If I am unable to collect my data during school hours, I will make arrangements with your consent and that of my participants', to perhaps do this after school hours, on days when school closes early or during weekends. I will also provide transport for some of my participants to return home, should the need arise.

Please note:

* Times and dates of this data generation process will be at your sole discretion. I have merely presented you with an outline of what I intend to do, however you are free to make any changes and suggestions, if necessary.
* Participation is completely voluntary, and participants have the right to withdraw from this study at any time. They will not be penalised if they choose to do so.
* Confidentiality and anonymity will be maintained at all times. The identity of your school and all participants will not be revealed at any time, as pseudonyms (different names) will be used to protect everyone's right to privacy.
* Any information provided by the participants will not be used against them, or against the school, and will be used for purposes of this research only.
* Participation in this study will not result in any cost to your school or the participants.

*Neither the participants nor your school will receive financial remuneration. However, costs incurred by participants as a result of their involvement in this project will be covered.

* This study does not intend to harm the participants in any way.

* All participants will be handed letters of consent which they will have to carefully read and sign, before I begin data collection.

I may be contacted at:

wandilezulu2@gmail.com/ 212507659@stu.ukzn.ac.za

Tel: 078 383 6823/ 067 101 0862

My supervisor's contact details are:

mudalyv@ukzn.ac.za

Tel: 031 260 3682

You may also contact the Research Office through:

Mariette Snyman

HSSREC Research Office,

Tel: 031 260 8350 E-mail: snymanm@ukzn.ac.za

If you would like any further information or if you are unclear about anything, please feel free to contact me at any time**.** Your co-operation and consent will be greatly appreciated.

If you grant permission to conduct this research at your school, please complete the form below and return to me.

Warm regards,

Mzwandile.

DECLARATION

I …… (full name/s of school principal) of ……..….. (name of school) hereby confirm that I understand the contents of this document and the nature of this research project, and I consent to the teachers participating in this research project. I also grant permission for my school to be used as the research site.

Additional consent

I understand that interviews will be audio-recorded and I grant permission for this.

YES/NO

I understand that the teachers and the school are free to withdraw from the research project at any time.

YES/NO

SIGNATURE OF SCHOOL PRINCIPAL **DATE**

…….. **……**…

APPENDIX B: EDUCATOR CONSENT LETTER AND DECLARATION

Informed Consent Letter to the Educator

Dear Educator

Ms/Mrs/Mr/Dr…….

Name of school ……..…..

Re: Permission to conduct a research study with you

I am writing to request your permission to conduct a research study with you. This research study is entitled:

An exploration of the integration of technology into mathematics teaching: The Case of 10 Schools in KwaZulu-Natal in the Umlazi District.

My name is Mzwandile Zulu and I am currently studying towards a Master's Degree at the University of KwaZulu-Natal (UKZN). As part of the requirements of this degree, I am required to complete a research thesis. This study focuses on exploring the use of educational technologies by mathematics teachers.

I require two mathematics educators of any gender or age, teaching any grade to participate in this research. I would be very grateful if you would agree to participate in this study.

If you agree to this, you will be invited to respond to a short questionnaire, be observed in the Smartboard classroom and be interviewed in pairs.

All discussions, interviews and dialogues with participants will be audio recorded using a dictaphone, and thereafter transcribed verbatim to produce transcriptions. This

research information (data) is required for the analysis of data and completion of the actual write up of the thesis. Collecting research information for this study will take approximately 30 minutes. The process of data collection, that is: response to the questionnaire and interview will take place in your school premises, with your permission. Times and dates will be discussed and arranged with you at a later stage. I will try to ensure that this takes place during your lunch breaks and/or free periods, in an attempt to avoid any disruptions during lessons. You will also be encouraged to eat their lunch during discussions and interviews, as well as make use of the school toilet should the need arise. I will not deprive you of these opportunities, especially since I intend to use some of your free time in order to collect sufficient data for my study.

If I am unable to collect my data during school hours, I will make arrangements with your consent, to perhaps do this after school hours, on days when school closes early or during weekends. I will also provide transport for some of my participants to return home, should the need arise.

Please note:

* Times and dates of this data generation process will be at your sole discretion. I have merely presented you with an outline of what I intend to do, however you are free to make any changes and suggestions, if necessary.
* Participation is completely voluntary and participants have the right to withdraw from this study at any time. They will not be penalised if they choose to do so.
* Confidentiality and anonymity will be maintained at all times. The identity of your school and all participants will not be revealed at any time, as pseudonyms (different names) will be used to protect everyone's right to privacy.
* Any information provided by the participants will not be used against them, or against the school, and will be used for purposes of this research only.
* Participation in this study will not result in any cost to your school or the participants.
*Neither the participants nor your school will receive financial remuneration. However costs incurred by participants as a result of their involvement in this project will be covered.
* This study does not intend to harm the participants in any way.

I may be contacted at:

wandilezulu2@gmail.com/ 212507659@stu.ukzn.ac.za

Tel: 078 383 6823/ 067 101 0862

My supervisor's contact details are:

mudalyv@ukzn.ac.za

Tel: 031 260 3682

You may also contact the Research Office through:

Mariette Snyman

HSSREC Research Office,

Tel: 031 260 8350 E-mail: snymanm@ukzn.ac.za

If you would like any further information or if you are unclear about anything, please feel free to contact me at any time**.** Your co-operation and consent will be greatly appreciated.

If you grant permission to conduct this research at your school with you, please complete the form below and return to me.

Warm regards,

Mzwandile

DECLARATION

I …… (full name/s of an educator) of ……..….. (name of school) hereby confirm that I understand the contents of this document and the nature of this research project, and I agree to participate in this research project.

Additional consent

I understand that interviews will be audio-recorded and I grant permission for this.

YES/NO

I understand that I am free to withdraw from the research project at any time.

YES/NO

SIGNATURE OF AN EDUCATOR **DATE**

…….. **……**…

APPENDIX C: PARTICIPANTS' QUALIFICATION

Teacher/Case	School	Years of teaching	Qualification(s)
Participant 1	A	19	Senior Teaching Diploma, B.Tech in Business Administration & BSc in Chemistry
Participant 2	B	35	B.Paed, Honours Degree, Master's Degree
Participant 3	C	13	B. Ed
Participant 4	D	4	BSc in Biochemistry & PGCE
Participant 5	E	10	B. Ed
Participant 6	F	4	B. Ed
Participant 7	G	30	Senior Teaching Diploma
Participant 8	H	33	B.Paed
Participant 9	I	23	Senior Teaching Diploma
Participant 10	J	8	B. Ed

APPENDIX D: PARTICIPANTS' QUESTIONNAIRE

External Variable		**Disagree**	**Agree**
E1.	There are sufficient technological tools for my teaching and learning in my school.		
E2.	There is enough institutional help for teachers to use technological tools for teaching.		
E3.	My institution provides me the training I need to confidently use technological tools in teaching.		
E4.	My school gives recognition to staff who use Technological tools in their teaching.		
E5.	I often lack time in using technological tools in my teaching		
E6.	I make use of technological tools for my teaching.		
Perceived Usefulness			
Q1.	Using the technological tools in my class helps me to control the pedagogy.		
Q2.	Using the technological tools in my class enhances the teaching performance.		
Q3.	I find the technological tools useful in my class.		
Q4.	Using technological tools makes it easier to attend to individual learners' needs.		
Perceived Ease of Use			
Q5.	It is easy to become skilful at using technological tools.		
Q6.	I find it easy to apply the technological tools in my class.		
Q7.	Using technological tools is easy and understandable.		
Q8.	Using technological tools is more flexible to teach than traditional one.		
Attitude Toward Using			
Q9.	Using technological tools in class is good.		
Q10.	My use of technological tools in class is favourable.		
Q11.	It is a positive influence for me to use technology in class.		
Q12.	I think it is valuable to use technological tools in class.		
Intention to Use			
Q13.	I intend to use technological tools in my class.		
Q14.	I intend to increase the occurrences of using technological tools in class.		
Q15.	I intend to use technological tools to provide multi-approaches on teaching.		
Q16.	I would love to use technology in my teaching of mathematics.		

APPENDIX E: OBSERVATION SCHEDULE

Name of an Educator:	**Role**:	**Observed by**:
Date of observation:	**Activity observed:**	**Location:**
Purpose of observation: Teacher usage of technological tools in the classroom.		

Time	**Observation**

APPENDIX F: DOCUMENTS ANALYSED

Selected documents	Analysed data
Document by Wilson-Strydom and Thomson (2005): The analysis of White Paper 2003	Conceptualising the integration of technology
Progress of the DBE with technology integration in Schools 2015	Strategies for effective technology integration in teaching
The status of ICT in education in South Africa and the way forward 2016 NECT	ICT in support of teaching and learning
Analysis of Basic Education Report on the ICT Rollout February 2018	DBE initiatives taken over the years regarding the integration of technology in education
Annual Performance Plan 2018/2019	Operation Phakisa the ICT integration in education

APPENDIX G: INTERVIEW SCHEDULE

A semi-structured interview guided by the following questions:

1. What were your learning experiences with computers where you obtained your teaching qualification?

2. Do you find educational technologies useful to your teaching of mathematics? Why or Why not?

3. Do you find educational technologies easy to use in your experience? Why or why not?

4. How do you integrate technology in your teaching of mathematics?

5. What type of challenges do you encounter regarding the integration of technology in your classroom? How do you deal with those changes?

6. From your experience of using technology when teaching mathematics, would you say you have seen an improvement in learners' performance? Yes/No, Why?

7. Would you recommend the educational technologies you have in your school for other schools? Why or Why Not?

APPENDIX H: ETHICAL CLEARANCE CERTIFICATE FROM UKZN

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

25 November 2019

Mr Mzwandile Wiseman Zulu (212507659)
School Of Education
Edgewood Campus

Dear Mr Zulu,

Protocol reference number: HSSREC/00000739/2019
Project title: An exploration of the integration of technology into mathematics teaching: The Case of 15 Schools in KwaZulu-Natal in the Umlazi District.

Full Approval – Expedited Application

This letter serves to notify you that your application received on 13 November 2019 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid for one year from 25 November 2019.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

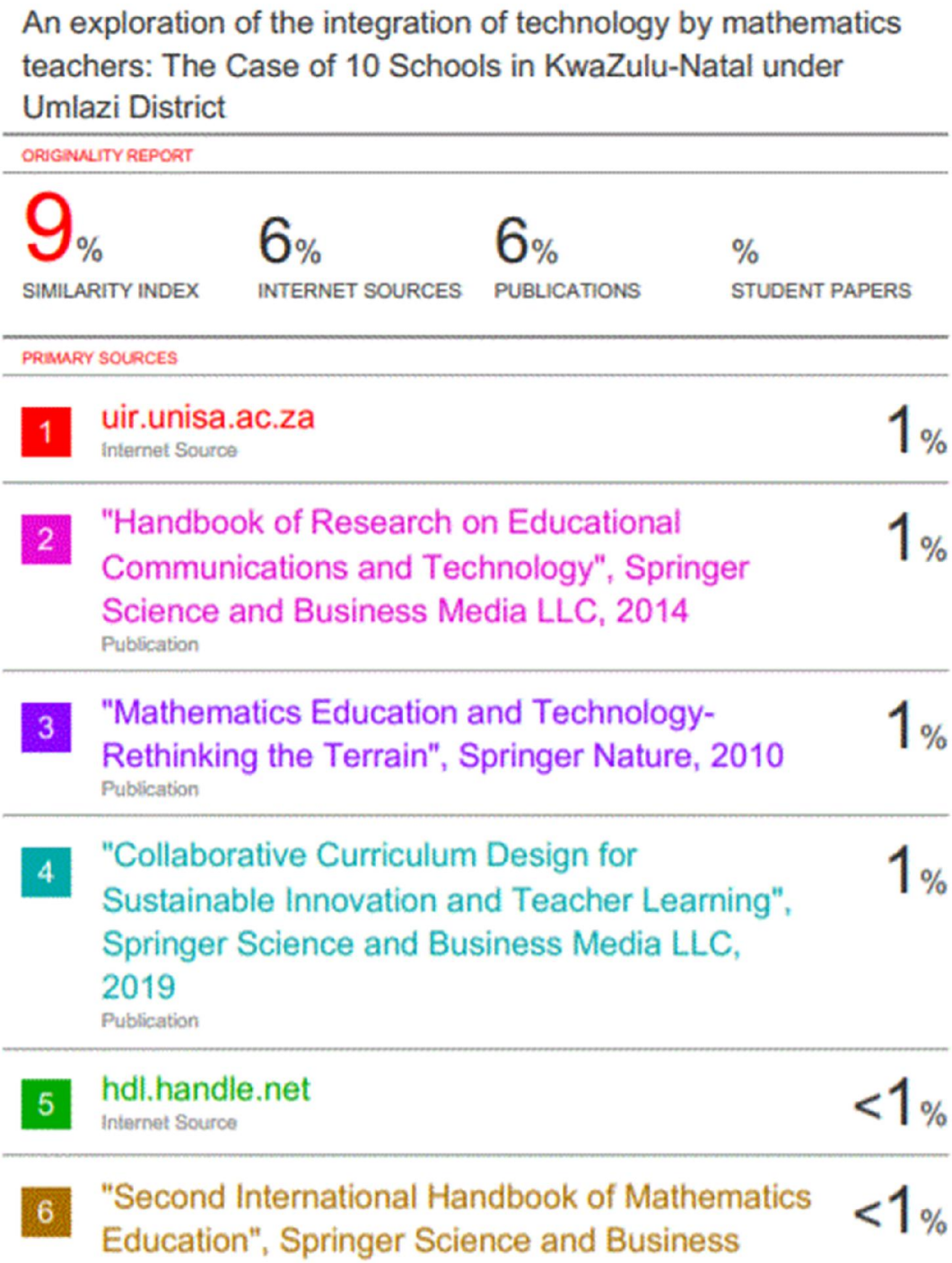
Yours sincerely,

Professor Urmilla Bob
University Dean of Research

/dd

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Website: http://research.ukzn.ac.za/Research-Ethics/

APPENDIX I: TURNITIN SIMILARITY REPORT



An exploration of the integration of technology by mathematics teachers: The Case of 10 Schools in KwaZulu-Natal under Umlazi District

ORIGINALITY REPORT

9%	6%	6%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	uir.unisa.ac.za Internet Source	1%
2	"Handbook of Research on Educational Communications and Technology", Springer Science and Business Media LLC, 2014 Publication	1%
3	"Mathematics Education and Technology-Rethinking the Terrain", Springer Nature, 2010 Publication	1%
4	"Collaborative Curriculum Design for Sustainable Innovation and Teacher Learning", Springer Science and Business Media LLC, 2019 Publication	1%
5	hdl.handle.net Internet Source	<1%
6	"Second International Handbook of Mathematics Education", Springer Science and Business	<1%

APPENDIX J: LETTER FROM EDITOR

CHRISTSON

S.christson@yahoo.com

11/05/2020

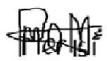
0613061718

To Whom It May Concern,

This letter serves to confirm that I, Peter Merisi, edited the thesis of Mzwandile Wiseman Zulu, entitled "An exploration of the integration of technology by mathematics teachers: the case of 10 schools in KwaZulu-Natal under Umlazi District".

Should you have any concerns, please do not hesitate to get hold of me.

Regards



Peter