EXPLORING THE EFFECTS OF INTEGRATING ICT TO TEACH GRADE 7 MATHEMATICS IN THE JOHANNESBURG EAST DISTRICT

by

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DECLARATION

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Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.

I declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

SIGNATURE:  DATE: 25/09/2024

DEDICATION

I dedicate this thesis to my late grandmother, Busisiwe Nxumalo. Her support is still felt even today. Her encouraging words still keep me going. From day one of my school life, she ensured that I went to school with a clean uniform, she made sure that I am not defined by my background amongst other learners. She continued with her support even when I started at the university. She might not have provided financial support, but her prayers and emotional support is all that I needed to pursue my career. I can never forget the tears of joy you shared on my first graduation ceremony. Her love for education has made me an inspiration in my family as I am the first person to go to university and all my siblings who comes after me, have seen the importance of education through me. I hope you will always share the proudest moments with me when I graduate even when you are in heaven.

May your precious soul continue to rest in peace.

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education kept us going. We were able to share information, lifting each other's spirit when we have reached rock bottom, the aim being far from giving up.

ABSTRACT

Mathematics is identified as one of the core disciplines, however, it remains the most challenging subject with very low achievement in South Africa. The poor performance could be as a result of primary reliance on textbooks as a teaching resource, utilising outdated methods to teach mathematics, inequality in teachers' mathematical content and pedagogical knowledge, and teachers' resistance to change. These challenges do not only affect mathematics results, but the economy of the country as a whole. There are improved pedagogical methods that are compatible with the digital generation. Therefore, the study aims to investigate the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District. The UTAUT has been chosen as the theoretical framework that underpinned this study. The researcher employed qualitative approach, and classroom observations, semi-structured interviews and focus group interviews were used to collect data. Eight grade 7 mathematics teachers were purposively sampled from four schools. The findings of the study revealed that ICT integration enhances the understanding of different mathematics content areas. There is a positive learner reaction towards the lessons. Performance expectancy, effort expectancy and social influence positively influence participants to integrate ICT to teach mathematics. Facilitating conditions has shown no significant effect on teachers' intention to integrate ICT. This study showed no clear indication of whether ICT integration has any effect on learner achievement. The study recommends intensive teacher training on how to effectively integrate ICT specifically in mathematics. The study also recommends the articulation of learner positive reaction due to ICT integration as a way of motivating teachers to refrain from using conventional methods of teaching and learning. Lastly, the awareness and thorough training on the mathematical software such as Geogebra is also recommended especially to primary school teachers.

Key words: Information Communication technology (ICT), mathematics pedagogy, ICT-based learning, digital tools, CAPS, technology integration.

ACRONYMS AND ABBREVIATIONS

2-D	2-Dimension
3-D	3-Dimension
4IR	4th Industrial Revolution
ASEAN	Association of Southeast Asian Nations
CAPS	Curriculum and Assessment Policy Statement
C-TAM-TPB	Combined Technology Acceptance Model - Theory of Planned Behaviour
DoE	Department of Education
GDE	Gauteng Department of Education
HoD	Head of Department
ICT	Information and Communication Technology
MM	Motivational Model
MPCU	Model of PC Utilisation
MST	Mathematics, Science and Technology
MySDLR	Supplementary Digital Learning Resources
SCT	Social Cognitive Theory
TAM	Technology Acceptance Model
TIMSS	Trends in International Mathematics and Science Study
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UNISA	University of South Africa
UTAUT	Unified Theory of Acceptance and the Use of Technology

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CHAPTER 1: ORIENTATION AND BACKGROUND OF THE STUDY

1.1 INTRODUCTION

Mathematics is still one of the most important subjects in the South African curriculum (DBE, 2011). It encourages and sharpens learners' cognitive skills, such as problem solving, critical and cognitive thinking. It is one of the primary determining variables in whether or not a student is ready to advance to the next grade level (DBE, 2011). The Trends in International Mathematics and Science Study (TIMSS) (DBE, 2019) uses mathematics to assess the efficiency of schooling around the world. In South Africa, there is poor performance in mathematics, which is evident in TIMMS. In 2019, Only 1% of grade 4 learners achieved in advanced international benchmark and only 6% achieved in high international benchmark (Mullis, Martin, Foy, Kelly, & Fishbein, 2020). The success of teaching and learning is evident through the attainment of the learning outcomes at the end of the teaching and learning period, through summative or formative assessment. Extreme concern is expressed by different stakeholders regarding poor performance in mathematics.

There are many challenges surrounding mathematics education as stipulated by different authors. Mabena, Mogkosi and Ramapela (2021) argued that mathematics is one of the most feared subject and learners have a negative attitude towards it, hence the poor performance. Furthermore, Osondu, Ogbonna and Umen (2022) posit that mathematics education is too prescriptive that it does not favour both teachers and learners, while creating bad memories for most generations. The CAPS document advocates for learner-centred methods, in which learners construct knowledge through hands-on activities, which facilitates critical thinking. Jojo (2019) indicated that, even though the curriculum changes, instructor’s mathematical practices remain unchanged. This is advocated by Mabena et al. (2021) as they posit that mathematics teachers are still using direct teaching methods. Teachers are continuously looking for improved tactics to help students achieve more. Some teachers choose to educate utilising internet videos and software tools, while others continue to use obsolete educational methods to teach mathematics. According to Viberg, Grönlund and Andersson (2020), knowledge is constructed through social interaction, in which technology is used. Integration of ICT should be considered one of the solutions that

can be utilised to increase mathematics achievement in South Africa (Saal, Van Ryneveld & Graham, 2019).

The rapidly increasing importance of technology in the twenty-first century has prompted calls for teaching and learning to be altered in order to educate students to compete in the global information economy. Learning in the twenty-first century necessitates the collaboration of well-trained instructors working in well-equipped classrooms and utilising technology in novel ways to promote a positive learning environment (Molnár, 2008). By offering access to novel applications and tools, technology enables learners to move beyond focusing on basic facts to broader global challenges (Van Melle & Tomalty, 2000). The world is rapidly approaching the fourth industrial revolution (4IR) era, and the question is whether the South African curriculum is prepared to train students to meet the needs of the digital world.

Liebenberg, Benade and Ellis (2018) refer to the current generation of young people as digital natives, describing them as having a natural knack for and high proficiency with technology. According to Tossavainen and Faarinen (2019), students utilise technology more in non-school related activities. This raises the question of whether this generation will embrace the incorporation of Information and Communication Technologies (ICT) in the classroom in the same way that they use their personal devices. The emphasis should be on building the nation and producing digitally capable citizens, which can only be accomplished by incorporating ICT into the teaching and learning process. This research looks into the effects of using ICT in the teaching and learning of mathematics in Grade 7.

1.2 BACKGROUND OF THE STUDY

The Curriculum and Assessment Policy Statement (CAPS) describes mathematics as a language that uses symbols and notations to represent numerical, geometrical and pictorial relationships (DBE, 2011). It recognises mathematics as a topic that fosters mental processes such as critical thinking and problem solving, which aid in decision making. Mathematics is one of the most essential subjects in the South African curriculum. Because it is one of the primary subjects, it plays a significant role in the progression of learners (DBE, 2011). According to Das (2019a), mathematics is a

distinct learning environment that supports the acquisition and development of special talents such as problem solving and cognitive skills.

Mathematics results from the National Senior Certificate for 2022 show that the pass percentage countrywide is 55%, the lowest of any subject (DBE 2022) and large-scale international studies such as Trends in International Mathematics and Science Study (TIMSS, 2019), reveal underperformance of South African learners in mathematics, which demonstrates that mathematics is a difficult subject to learn. To improve the performance of learners, teachers should experiment with different methods of teaching mathematics rather than using traditional teacher-centred practices that rely on textbooks, pens and paper (Minty, 2017). Tamam and Dasari (2021) proposed using Geogebra software, an interactive geometry, algebra, statistics and calculus application, as a medium to enhance teaching and learning in mathematics, particularly in geometry, algebra, and statistics, because it aids in the visualisation of objects. In Indonesia, the curriculum document clearly specifies that schools must support the use of ICT in the classroom in order to improve the effectiveness of teaching activities (Mailizar & Fan, 2019).

The application of ICT in mathematics education has been the subject of much research. Many studies, for example, Das, (2019a); Graham, Stols and Kapp, (2020); Henderson (2020) have indicated its potential benefits in improving learning outcomes and student engagement. Interactive software, online tutorials, and educational apps, for example, have been shown to enable personalised learning, visualisation of abstract concepts, and quick feedback. The use of ICT in mathematics instruction leads to considerable improvements in students' mathematical achievement, according to a meta-analysis of several research studies conducted by Abdullahi and Sejaro (2022), Graham et. al (2020) and Muhazir and Retnawati, (2020). However, there have been concerns and studies that emphasise the problems and potential disadvantages of using ICT in mathematics teaching (Aduwa & Iyamu, 2005). ICT use in mathematics education has received much attention in research, with some studies emphasising its positive impact on learning outcomes and others emphasising the problems and barriers to its adoption (Dhital, 2018; Kiapene, 2022; Kaur, 2023; Mir, 2019) and providing additional insights into various features of ICT use in mathematics teaching (Azizah, Kusmayadi & Fitriana, 2021; Das, 2019a; Tamam & Dasari, 2020).

1.3 SIGNIFICANCE OF STUDY

Mathematics is incredibly significant in people's daily life since it helps with decision making, problem solving and critical thinking (DBE, 2011). The identified issues are learners' poor mathematics performance and the usage of obsolete teaching methodologies. Teachers are constantly looking for improved tactics to help students improve their arithmetic ability. Mathematics is a difficult subject that many students fear because they incorrectly believe it assesses one's intellectual capacity. With technology's rising significance in knowledge acquisition, this study is vital because the results might provide insight into the consequences of incorporating ICT in Grade 7 mathematics classrooms. This study is based on the research of Tossavainen and Faarinen (2019), who are concerned about whether spending heavily on the provision of ICT is able to boost mathematical effectiveness and efficiency. Finally, this study might lay the groundwork for future studies. The goal of this research project is not only for South African education, but also for other countries who want to use technology in Grade 7 mathematics classrooms.

1.4 PROBLEM STATEMENT

Mathematics teaching and learning is not achieving the intended results outlined in the South African curriculum and policy, according to the 2019 TIMSS results (DBE, 2019). TIMSS is used to examine mathematical and scientific knowledge, allowing participating countries to track their educational achievements and how they evolve over time (DBE, 2019). According to the TIMSS findings, South Africa is one of the lowest performing countries in mathematics. The TIMSS performance target is 500 points, and South Africa scored the lowest of any country (DBE, 2019). Even though there is a modest increase, the score remains the lowest because it has never met the set criterion of performance. The poor performance in mathematics is particularly concerning since it means that South African education system produces learners who are unable to contribute to the country's economy.

There are various challenges amounting to the underperformance in mathematics in South Africa. Teachers are primarily reliant to textbooks to teach mathematics (Meeran & Van Wyk, 2022). To Attest to this, Taylor (2019) posit that mathematical textbooks are seen as significant contributors to teaching and learning of mathematics. Furthermore, Taylor (2019) points to inequality in teachers' mathematical content and

pedagogical knowledge. Similarly, Jojo (2019) worries about poor teaching of mathematics in South Africa. Authors such as Valoyes-Chávez (2019) points learner's poor performance to teacher's resistance to change. In this study, resistance to change is denoted as the utility of outdated teaching and learning methods. Jojo (2019) also argue that even though the current curriculum advocates for various teaching and learning styles, mathematics teacher's practices remain unchanged.

Grade 7 learners experience a lot of challenges as they transition to secondary/high school level. Academic struggle, inferiority complex and building relationships with teachers are listed by Treceñe, Negros, Paler and Cornillez (2021) as some of the challenges that Grade 7 learners face. With such challenges in mind, if learners are underprepared in primary level, this might cause a long term effect in achieving mathematical skills such as critical thinking, problem solving and cognitive development. If these problems are not addressed or given attention, they can have a negative influence not only in the classroom but also in the country as a whole. As a mathematics teacher, I believe that effective teaching and learning, complemented by the use of appropriate teaching and learning materials, is the key to attaining the best results.

With the previously highlighted problem of poor mathematics performance in mind, the purpose of this study is to investigate the effects of integrating ICT in a Grade 7 mathematics classroom in Johannesburg East District. This research aims to determine whether teachers can use ICT to improve the quality of education, specifically mathematics performance, both locally and globally. The study also intends to shed light on the significance of implementing and integrating modern teaching approaches that are compatible with the digital generation.

1.4 RESEARCH QUESTION

The main research question is: *What are the effects of integrating ICT to teach Grade 7 mathematics in the Johannesburg East District?*

1. What are the pedagogical benefits of integrating technology in Grade 7 mathematics classrooms?
2. What are the challenges in implementing technology in Grade 7 mathematics classrooms?

3. How is ICT integrated into Grade 7 mathematics classrooms in the Johannesburg East District?
4. What are Grade 7 teachers' perspectives on the integration of ICT in their mathematics classroom?

1.6 AIM AND OBJECTIVES

The purpose of this research is to investigate the effects of integrating ICT to teach Grade 7 mathematics in the Johannesburg East District.

The study's goals are as follows:

1. To investigate the pedagogical benefits of integrating technology in Grade 7 mathematics classrooms.
2. To explore the challenges in implementing technology in Grade 7 mathematics classrooms.
3. To develop understanding of how ICT is integrated in Grade 7 mathematics classrooms in the Johannesburg east district.
4. To investigate Grade 7 teachers' perspectives on the integration of ICT in their teaching of mathematics.

1.7 THEORETICAL FRAMEWORK

Theoretical frameworks serve as a review of existing theories that aid in the direction of the research investigation (Cohen, Manion & Morrison, 2018). The theoretical framework serves as a point of reference, establishing a link between existing information and yet-to-be found knowledge (Cohen et al., 2018). The researcher can draw on prior knowledge in the subject, and the theoretical framework serves as the foundation for hypothesis testing (Cohen et al., 2018).

1.7.1 Unified Theory of Acceptance and Use of Technology

The theory used in this study is the Unified Theory of Acceptance and Use of Technology (UTAUT). This theory, according to Venkatesh, Morris, Davis and Davis (2003), was developed in order to unite the various theoretical models that emerged as a result of the application of ICT in organisations. Based on conceptual and empirical commonalities, there was a need to unify these models in order to avoid

having to choose constructs among models while neglecting contributions from alternative models (Venkatesh et al., 2003). This theory recognises four constructs as direct predictors of user acceptability and usage behaviour. Performance expectancy, effort expectancy, social influence, and conducive conditions are examples of direct determinants. These factors were used to lead this research by analysing teachers' experiences and perspectives in order to determine if they have any effect on the integration of ICT in Grade 7 mathematics classes. These factors not only help to guide this research, but they also establish the groundwork for the analysis, interpretation and discussion of the findings.

Performance expectancy is defined as the degree to which a person believes that a system can help them improve and achieve better results (Venkatesh et al., 2003). This determinant's belief is based on the system's utility, motivation and benefits (Venkatesh et al., 2003). In this study, performance expectancy is used to determine whether Grade 7 mathematics instructors feel it is useful to integrate ICT and whether using technology in the classroom is beneficial. Performance expectancy also helps determine whether or not this factor has any effect on improving teacher teaching techniques and learner performance in mathematics. Overall, this factor aids in answering the question of the advantages of employing technology in the Grade 7 mathematics classroom.

Effort expectancy considers how simple it is to use a particular system (Venkatesh et al., 2003). This indicates that individuals are able to assess the complexity, difficulty, and effort required to use technology before accepting it. In this study, effort expectancy is utilised to investigate teachers' experiences with ICT integration. The research concentrates on understanding how technology is used, based on the complexity, difficulty and amount of effort required.

Social influence is defined as the degree to which a person perceives a particular system based on how important individuals in their immediate surroundings regard it (Venkatesh et al., 2003). In an educational environment, this means that one's use and acceptance of technology is influenced by the opinions of others (colleagues, department heads and principals) on whether or not to use technology. This factor will be used in this study to determine whether other colleagues, the departmental head

and the principal have any influence or play any role in encouraging teachers to adopt ICT in Grade 7 mathematics classrooms.

The final determinant is ***favourable conditions***, it is further defined as a person's belief that a particular organisation has the necessary technological infrastructure to support the use of ICT (Venkatesh et al., 2003). This factor is highly important in this study since it will help understand teachers' experiences with incorporating ICT in mathematics courses. This variable aids in determining whether there is adequate infrastructure to enable the use of ICT in the classroom and determining whether teachers receive any training and empowerment regarding digital devices and how to successfully use them. Overall, this factor aids in determining whether the essential resources exist to allow ICT integration, which may include ICT knowledge, infrastructure, support and skills.

1.8 LITERATURE REVIEW

This section gives a brief outline of literature reviewed to support the research which includes sub-sections on mathematics pedagogy, ICT knowledge of the teachers, and learners' usage of technology.

1.8.1 Mathematics Pedagogy

Mathematics teaching and learning in South African schools is not providing the desired goals as specified by policy and in the curriculum (DBE, 2018). The Department claims that mathematics has had lower learner accomplishment at the national, regional and international levels which could demonstrate the ineffectiveness of mathematics teaching and learning approaches. Mathematics is considered the most difficult subject to learn and this is not helping with the focus on the use of traditional teacher-centred practices. Traditional teaching techniques involve the teacher completing tasks on the board with the learners with the goal of attaining that one correct answer. As a learning resource, teachers rely primarily on textbooks (Meeran & Van Wyk, 2022).

The Department (DBE, 2018) feels that a game-changing initiative is needed to change the way mathematics is taught. Because students live in a technological era (4IR), technology integration should be examined as one of the solutions to the

teaching and learning process. The importance of using technology in mathematics is a hot topic around the world (Tossavainen & Faarinen, 2019). Indonesia is one of the countries that sees ICT as a possible tool for improving educational quality (Mailizar & Fan, 2019). According to Perienen (2020), who conducted a study on the integration of technology in mathematics education, technology has pedagogical affordances that can assist in addressing low performance in mathematics education. Young, Gorumek and Hamilton (2018) conducted a study on the usefulness of technology in the classroom and concluded that technology can improve delivery and clear comprehension in mathematics teaching and learning. They also stated that teachers should continue to integrate technology into the mathematics classroom.

The use of outmoded teaching and learning tactics is identified as a gap in this study, necessitating this research, which intends to investigate the effects of integrating ICT to teach Grade 7 mathematics in the Johannesburg East District. It seems that in promoting the adoption of strategies that would improve creative thinking and problem-solving skills through administering learner-centred teaching and learning, would improve mathematics performance.

1.8.2 ICT Knowledge of the Teacher

The use of technology in the classroom is heavily influenced by the teacher's beliefs about knowledge acquisition and content comprehension. Teachers think that if students understand mathematics, they should demonstrate their knowledge by solving problems without the use of technology (Marbán & Malenga, 2019). Perienen (2020) argues that while the majority of teachers demonstrate technical skills by using their devices on a daily basis, they are still apprehensive and anxious about incorporating ICT in the mathematics classroom. However, Mailizar and Fan (2019) argue that teachers lack adequate ICT competence. Saal et al. (2019) revealed that teachers lack assistance for incorporating technology into the classrooms and face ICT obstacles in teaching and learning. This means that the availability and use of technical instruments might nevertheless produce unsatisfactory results if they are applied incorrectly. According to Viberg et al. (2020), if schools want to employ digital resources in mathematics instruction, instructors must be trained on how to use them effectively.

According to Tossavainen and Faarinen (2019), the use of technology in mathematics instruction varies greatly depending on the availability of technology devices, the teacher's choice, and the capacity to use them. Graham, Stols, and Kaap (2020) disagree, believing that the availability of resources, technical assistance, and teacher competence does not guarantee that instructors will use ICT. According to Zen, Zukdi, Zulfahmi and Trinova (2022), the function of ICT is advantageous to teachers as well as learners since it allows them to enhance their teaching abilities. Virbeg et al. (2020) suggest that if teachers want to integrate ICT in mathematics education, they must first grasp how digital tools work. The preceding reasons are reinforced by Perienen (2019), who believes that no paradigm shift in education can occur and be successful without involving teachers, and that there is currently demand on educators to be digitally savvy. Virbeg et al. (2020) argue that in the study they conducted on the integration of ICT in mathematics, teachers did have ideas on how to use digital tools in an effective and beneficial manner. In contrary, other researchers like Abdullahi and Sijaro (2022), Appavo (2019) and Ardic (2021) advocated that teachers do not have ICT knowledge and how to integrate it. In conclusion, Perienen (2019) contends that the rapid increase in knowledge acquisition through technology emphasises the need for instructors to be technologically competent.

1.8.3 Learners' Usage of Technology

Today's children are thought to be digitally proficient since they are always attached to their gadgets. Viberg et al. (2020) determined that students are not as digitally adept as professors appear to expect. Tossavainen and Faarinen (2019) disagree because they feel that learners use technology more in non-school-related activities such as playing games and using social media platforms, however the effect is contrary when it comes to school-related work. Giving learners digital devices and expecting them to accomplish everything on their own will result in less effective ICT integration in the classroom. According to Tossavainen and Faarinen (2019), learners who prefer pen and paper to study mathematics have stronger intrinsic motivation, whereas those who utilise ICT have extrinsic incentive. This raises the question of whether ICT integration would produce learners who are not self-motivated; thus, this research could also provide insight into learners' usage of technology as well as the impacts of ICT integration in Grade 7 mathematics classes.

Zen et al.'s (2022) study on using ICT-based learning to boost student motivation discovered that when ICT is integrated into teaching and learning activities, learners are strongly driven to learn. Tossavainen and Hirsto (2018), on the other hand, discovered that the introduction of iPads in the classroom had no effect on motivation or performance in mathematics. Integration of ICT in mathematics education can only be successful if teachers understand ICT and how to use it in the classroom. If learners are left alone with digital tools, the integration effect will never create high-quality outputs. Virbeg. et al (2020) observed how teachers provided learners with digital resources and then let them to figure out how to use them on their own. According to the findings of this study, learners who do not utilise technology perform significantly better than learners who use technology in an unstructured manner.

1.9 RESEARCH METHODOLOGY

This section gives a brief outline of the most important aspects of the research which serves as a guide on how this research is conducted, taking into account the assumptions that align with this study. These aspects include research paradigm, research approach and research type.

1.9.1 Research Paradigm

Cohen et al. (2018:8) define a paradigm as "a way of researching a phenomenon, a world view, a view of what counts as accepted, a set of principles, and a way of pursuing knowledge" based on Kuhn's (1962) work. The assumptions of the research paradigm are founded on epistemology, ontology and methodology. This study employed an interpretivist paradigm to carry out this research. Interpretivists want to investigate the meaning of the problem at hand via the eyes of the participants (Creswell & Creswell, 2018). An interpretivist approach is concerned with interpreting and comprehending how and why individuals behave the way they do. It is based on people's thoughts, points of view and observations of how people do things. Denzin and Lincoln (2018) emphasise the social environment in their interpretivist approach. Based on the assumptions made above regarding the interpretivist paradigm, it is consistent with the proposed study where interviews and observations with participants are conducted to investigate the effects of incorporating ICT in the Grade 7 maths classroom and focus group interviews were utilised to gather insight into how ICT integration in Grade 7 mathematics classrooms may be sustained.

1.9.2 Research Approach

The study's goal was to investigate the experiences of Grade 7 mathematics teachers in the Johannesburg East District in integrating ICT and comprehend the consequences of incorporating ICT in Grade 7 maths classrooms. The qualitative approach was chosen based on the nature of the research and the paradigm of choice. A qualitative approach is one that seeks to understand and investigate the meaning that people attach to a phenomenon (Creswell & Creswell, 2018). A qualitative strategy is one that focuses on understanding people's views and attitudes through various approaches such as observations to acquire in-depth information (Cohen et al., 2018). This strategy is useful because, as a researcher, I experienced what the participants are experiencing by being in the same environment.

1.9.3 Research type

Among the many definitions of a case study, Cohen et al. (2018) draw on the work of Yin (2009), who defined it as "a study of a case in a context, and it is important to set the case within its context (and rich descriptions and details are often a feature of a case study)". A case study, according to Cohen et al. (2018), offers readers the opportunity to understand ideas within unique circumstances involving actual individuals, more clearly than simply providing them with theories and principles., allowing them to understand ideas more clearly than simply providing them with theories and principles. Cohen et al. (2018) suggest that the case study's power rests in the observation in real context, which leads to an in-depth comprehension of the scenario. There are various types of case studies that may be undertaken, but this research used a multiple case study approach. Multiple case studies are defined as a collection of individual studies undertaken to obtain more specific information (Cohen et al., 2018). The reason for conducting a case study was to collect data from numerous schools (four schools) and different teachers (two Grade 7 mathematics teachers each school) in order to collect sufficient data.

1.10 RESEARCH METHODS

This section gives a brief discussion of sampling method and data collection methods. Data collection methods that were adopted in this study includes observations, semi-structured interviews and focus group interview.

1.10.1 Sampling

Sampling is the procedure of selecting persons to take part in the research project. The essential criterion for qualitative research sampling technique is the richness of the information to be acquired (Crabtree & Miller, 2022). Because qualitative research will direct the research study, a purposive sample was used. Purposive sampling is a component of qualitative research, according to Cohen, et al. (2018). This sort of sampling was used since it resulted in the selection of competent individuals who were able to supply the necessary information based on the situation at hand. Purposive sampling's primary goal is to collect detailed information from those who are qualified to provide it (Cohen et al., 2018). Four primary schools were selected and two experienced Grade 7 mathematics teachers were sampled from each school, totalling eight teachers. The reason for selecting experienced teachers is that due to their years of expertise in the subject, they are seen as qualified individuals capable of providing in-depth information.

1.10.2 Data Collection Methods

Traditional qualitative data collection methods according to Creswell and Creswell (2018), comprise observations, interviews and a focus group interview. In this section data collection techniques used in this study are discussed.

1.10.2.1 Observation

Participant observation is one of the data collection strategies that produces detailed and comprehensive information. According to Cohen et al. (2018), observation is more than merely gazing. During observations, the researcher interacts with people in the specific situation while documenting how they behave and interact. In other circumstances, the researcher not only observes but actually takes on the roles of participants. This is advantageous because if an observer fully participates, they personally comprehend and experience what the participants go through, and can easily perceive things from their point of view. Because data is collected in a natural situation, the researcher is able to capture the moment as it happens, limiting bias. According to Cohen et al. (2018), using observations as a major method has the potential to create genuine and authentic data. This form of data collection was used to understand how ICT is integrated in Grade 7 mathematics classrooms.

1.10.2.2 Semi-structured Interviews

Cohen et al. (2018) believe that an interview is a flexible form of data collection since its order may be controlled and the interviewer is able to press for complete responses. Interviews allow participants to share their views, experiences, perceptions and practices. During interviews, words spoken are important, but facial expression and gestures also act as additional information (Flick, 2022). Semi-structured interviews were used to gather information in this research. According to Cohen et al. (2018), in semi-structured interviews open-ended questions and topics are given with tailored sequence. According to Brinkmann (2018), open-ended questions demand more detailed information. Semi-structured interviews have the power of channelling the conversation because they allow an interviewer to apply open-ended questions that are followed up by probes (Adeoye-Olatunde & Olenik, 2021). Probes allow an interviewer to ask participants to elaborate, extend their responses, or give examples in order to obtain rich information (Cohen et al., 2018). Semi-structured interviews were conducted with participants to explore the pedagogical benefits to integrating ICT, as well as the challenges in implementing ICT in Grade 7 mathematics classrooms. Follow-up questions are also permitted in semi-structured interviews (MacMillan & Schumacher, 2010).

1.10.2.3 Focus group interviews

This is the sort of group interview that relies on participant interaction to discuss the topic provided by the researcher, resulting in a collective view (Cohen et al., 2018). Focus group interviews have the potential to yield insights that would not have been obtained through one-on-one interviews. Focus group interviews are also useful for qualitative research because they produce abundant data. This method of data collection was used in this study to investigate ICT grade 7 teachers' perspectives on the use of ICT in Mathematics classrooms based on performance expectancy, effort expectancy, social influence, and facilitating conditions, with the goal of determining what can be done to effectively sustain the use of ICT mathematics classrooms in the Johannesburg East District. The sample was chosen through purposive sampling. Purposive sampling is a technique used to select specific people, situations, or events on the grounds that can supply the needed information (Cohen et al. (2018). Eight educators from four public primary ICT schools formed the sample.

Participants	No of participants
Grade 7 Teachers (2 from each school)	8

All interviews were tape recorded and transcribed verbatim for analysis.

1.10.3 Data Analysis

Understanding, interpreting and attempting to make meaning of data obtained is what qualitative data analysis entails (Cohen et al., 2018). Thematic analysis was used as a method of data analysis as it is a strategy for identifying patterns in collected data (Maguire & Delahunt, 2017).

The steps of thematic analysis are briefly described below.

Step 1 Acquaintance: This is the first step of theme analysis, in which the researcher engages with and gains insight into what appears to be a significant amount of data (Terry, Hayfield, Clarke & Braun, 2017). This stage is critical because if it is not completed correctly, the entire analytic process may fail. In practice, this stage entails making notes based on reading and re-reading all of the material in the form of texts (Terry et al., 2017).

Step 2 Creating codes: According to Terry et al. (2017), code creation entails providing relevant labels in a thorough and methodical manner. Flick (2022) explains that coding is the process of gathering comparable statements and labelling them.

Step 3 Creating themes: A deeper comprehension of data as a result of familiarisation and code production leads to the development of themes. According to Terry et al. (2017), this is a particularly active step because it involves the finding and development of patterns in a dataset. This step also entails grouping data with similarities and correlations into possible themes (Terry et al., 2017).

Step 4 Examining topics: This step is equally critical since it requires further moulding of the ideas, clarity and making rejections, if necessary (Terry et al., 2017). The review of themes begins with determining whether the generated themes match the original meaning of the raw data and then moves on to determining whether the created themes answer the research question (Terry et al., 2017).

Step 5 Establishing themes: The produced and reviewed topics are then defined and identified based on the information available by assigning working titles to them (Terry

et al., 2017). "Theme names must give a clear indication of the content within the theme and draw the reader into analysis," write Terry et al. (2017:31).

Step 6 Report Creation: This is the final stage of theme analysis, indicating that data analysis is complete. It entails writing up the findings and explicitly answering the study question (Terry et al., 2017).

1.11 TRUSTWORTHINESS

According to Lincoln and Guba (1985), believability, transferability, dependability and confirmability can be used as criteria to determine whether a qualitative study is good or legitimate. Validity assesses the efficacy of research; it is meaningless if the research is invalid (Cohen et al., 2018). The following criteria are given by Lincoln and Guba (1985), explaining how they will be met in this study.

Credibility is concerned about the truth in research (Maree, 2016), it is also concerned about whether the participants are impressed that the findings of the study are the representation of their experience (Treharne & Riggs, 2015). *Transferability* is concerned about the results of the study being applicable to other settings (Maree, 2016), it answers the question of whether the findings can be applied to another situation (Triharne & Riggs (2015). *Dependability* is concerned about whether the same results would be produced if someone else were to conduct that particular research (DeCarlo, 2018), while *confirmability* is concerned about the quality of the data collected, whether it represents the participant's views or the imaginations of the researcher (Triharne & Riggs, 2015). This study is a multiple case study, and the use of four schools plays a role in ensuring that data is credible and confirmable.

1.12 ETHICAL CONSIDERATIONS

According to Creswell and Cresswell (2005:22), it is critical in research to consider ethical considerations involving a research site and to obtain authorisation before entering a location. Therefore, in order to demonstrate that the research study is genuine and there is adherence to the accepted standards, ethical clearance through the University of South Africa's (UNISA) ethical clearance board in the college of education needed to be obtained. The permission to conduct the research was requested from the Department of education, together with the authority from the schools involved. The researcher protected the respondents in this study by ensuring

that data were collected while following all ethical norms. Changing participants names to pseudonyms, ensured that all participants' confidential information was encrypted and kept secret. Co-researchers re-evaluated and re-coded the transcriptions to improve the credibility of the interview results (Miles, Huberman& Saldaña, 2013).

1.13 LIMITATIONS OF THE STUDY

The study was limited to four schools, with only two Grade 7 mathematics instructors sampled from each school, for a total of 8 participants. The sample size is very small in order to obtain in-depth and rich data in accordance with the parameters of a qualitative study. Because the observations took place during normal school hours, there could have been disruption to routine classroom teaching and learning. The fact that the research study used a limited number of schools and a small number of participants is one of the study's constraints. Another drawback is that data collection takes a lengthy time due to the availability of the participants.

1.14 DEFINITION OF CONCEPTS

As part of contextualising this study, it is important to give meaning and understanding to certain terms used within this study. These key concepts are used throughout the dissertation.

1.14.1 Mathematics Pedagogy

Mathematics, according to the curriculum, aids in the development of mental processes that promote critical thinking and problem solving, which aid in decision making (DBE, 2011). Mathematics pedagogy is concerned with how teachers assist students in understanding, doing and applying mathematics rather than imparting knowledge. Mathematical pedagogy is concerned with how well teachers identify learning resources and technology tools in order to use them effectively during instruction (Mishra, 2014).

1.14.2 ICT

Tossavainen and Faarinen (2019) define ICT as a special area of information technology that relates to devices used for communication and interaction with digital information. Ameen, Adeniji and Abdullahi (2019) define ICT as a tool that consists of

electronic devices used for information and communication purposes in institutions, organizations, by students, and individuals in general.

1.14.3 ICT-Based Education

ICT-based learning is a style of learning in which technology is employed as a learning resource, allowing learners to be self-directed in their learning (Zen et al., 2022). According to Zen et al. (2022), ICT-based learning is an innovative approach to learning that adapts to current ICT advancements while making it easier for teachers to deliver content and learners to access information linked to teaching and learning.

1.14.4 Digital Tools

Digital tools, according to Das (2019), cover a wide range of technology such as a desktop, notebook, digital cameras, the internet, cloud computing, area networking, streaming, applications, and visual environment. Artifacts created by technology assist humans in various tasks such as problem solving and making life easier (Virbeg et al., 2020).

1.14.5 CAPS

The Curriculum and Assessment Policy Statement is a comprehensive policy document that specifies how the South African curriculum should be implemented, including learning programme criteria, policy on learner progression standards and a national assessment protocol (DBE, 2011). This statement also summarises the specific goals of mathematics education, one of which is to develop a critical understanding of how mathematics is used in social, environmental, economic, and cultural connections (DBE, 2011).

1.14.6 Technology Integration

According to Virbeg et al. (2020), this idea refers to employing technology efficiently in order to positively contribute to the performance of complex information systems, which encompasses both formal and informal usage of ICT in the classroom by teachers and students. Ameen et al. (2019) state that ICT integration should never be perceived as a method of replacing existing teaching methods, but rather as a crucial tactic to promote new ways of teaching and learning.

1.15 OUTLINE OF THE CHAPTERS

Chapter 1: This is the first chapter, and it describes the study's orientation. It is a critical component of the research since it outlines critical information regarding the research to be undertaken. It introduces readers to the topic, the recognised problem, the importance of the study, and how the researcher intends to analyse the problem. It focused on the study's introduction, background, problem description, goals and objectives, justification, and importance. The methods of research, theoretical frameworks, and significant themes were also outlined. The chapter division was provided.

Chapter 2: The second chapter provides an in-depth assessment of the literature. It concentrates on the study's contextual, theoretical, and conceptual foundations. The theoretical framework is created with the goal of laying the groundwork for the results' analysis, interpretation and generalisation. The literature review is conducted to examine how previous researchers have investigated the topic, as well as how this information may be used to lead this research study. Finding articles pertinent to the study to be undertaken with the goal of examining the understanding of existing knowledge that is relevant to the study to be conducted, is what a literature review comprises. This chapter also discusses the theoretical framework that guides this research.

Chapter 3: This chapter concentrates on the research methodology, which includes research design (paradigm, approach, and research type) and research procedures. It will also include a discussion of trustworthiness and an ethical examination of the study's participants. the type of research that is to be conducted, and the method that is used to do the research. Participants are chosen at this stage, with consideration given to how their privacy is safeguarded and their safety.

Chapter 4: This chapter presents the data analysis and interpretation. The study's findings are reviewed in depth and compared to those of other research based on a review of the literature. This is a critical stage of the research because it addresses the study's question. It is critical since it determines the study's success or failure; therefore, if not done carefully, it may lead to incorrect interpretation of the results.

Chapter 5: This is the concluding chapter, and it signals the conclusion of the research. It offers a commentary based on the study's findings. It summarises and

presents the study's conclusion based on data analysis and interpretation. It also offers recommendations and suggestions for future study. The study's limitations are examined, and the final concluding remarks are presented.

1.18 CHAPTER SUMMARY

The first chapter of this research study is an introductory phase which gave a brief outline, yet detailed content on what the study is about. It introduced the study and outlined the background of the study explaining the need for this study through problem statement and significance of the study. Research questions and objectives of the study are presented. The route of this study in terms of methodology, data analysis method and ethical considerations was briefly explained. The following chapter gives a detailed discussion of literature review and theoretical framework.

CHAPTER 2: REVIEW OF THE LITERATURE AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The innovation of technology has facilitated drastic changes in different sectors, including that of education. Due to the innovation and adoption of technology, a number of studies have been conducted which have led to the emergence of different theories of acceptance and usage of technology. One of the objectives of this study was to identify the benefits and the challenges that are experienced due to the adoption and integration of Information and Communication Technologies (ICT) in mathematics classrooms. This study also aimed to explore teacher's experiences and views on the utility of ICT in the classroom. To attain these objectives, the need to clarify the theories to be used and the need to review the literature is necessary.

The chapter begins with offering clarity on research evidence that serves as the background of this research. A review is conducted on the policies that underpin the incorporation of technology tools in the education sector, internationally, in Africa and in South Africa. The level of application of ICT globally, in African countries and in South African schools is presented as benefits, challenges and factors affecting the adoption and implementation of technology. Teachers' perceptions on ICT use in mathematics classroom context are also discussed. The last section presents a detailed description of the theory that forms the baseline of this research, including the origin and history of the theory as well as key aspects of the theory, such as performance expectancy, effort expectancy, social influence and facilitating conditions. These key constructs are explained on how they will assist during the analysis and interpretation of the results of exploring teachers' perception on the integration of ICT.

2.2 REVIEW OF LITERATURE

This section reviews existing research that is related to teachers' experiences on the integration of ICT in mathematics classrooms. Reviewing the literature assists in gaining an insight into how other researchers investigated the research problems related to the current study. The focus on this review is on the aspects mentioned above in the introduction; however, this discussion does not focus only on the South

African context, but it looks at this matter globally, in African countries and finally, in South African schools.

2.2.1 The Role of ICT in Education

The integration of ICT in education sector plays a significant role in teaching and learning and eventually in the development of vital skills required to survive in the technological era. Ever since the inception of technology, all around the world, the governments of different countries, in collaboration with the departments of education, have worked to ensure the adoption of ICT in schools to advance pedagogical innovations (Ab Jalil, Rajakumar & Zaremohzzbieh, 2022). Researchers such as Ameen et al. (2019) and Oke and Fernandes (2020) have outlined and discussed the role played by ICT in advancing the quality of pedagogical processes in schools. For example, Ameen et al. (2019) believes that the nation can rely on ICT in building self-reliance in the education system.

Through the incorporation of ICT in education, a society that is digitally competent in the global market place is promoted. Razak, Jalil and Ismail (2019) and Pultoo et al. (2020) strongly argue that the integration of ICT in the classroom equips learners with skills needed in the 21st century that ensures digital competency in the global market place. Twenty first century skills have been successfully identified by Henderson (2020) as problem solving, critical thinking, collaboration, creativity, leadership and self-direction which are vital in the fourth industrial revolution (4IR). The adoption of e-learning significantly contributes to the promotion of the 4IR through teaching, even though African countries are not prepared to exploit the opportunity of utilising ICT in facilitating learning and teaching (Oke & Fernandes, 2020). However, Oke and Fernandes (2020) also questions the utility of ICT whether it will ever become a normative tool. This discussion brings us to the investigation of national policies that underpin the utility of ICT in schools, from a global perspective, to African countries and finally, in South Africa.

2.2.2 Policies Underpinning the Utility of ICT in Schools

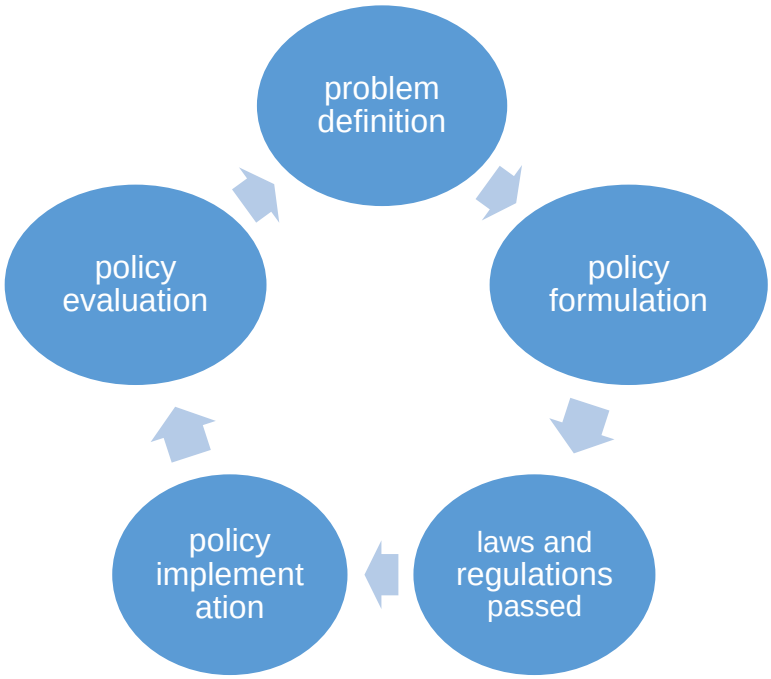
The implementation of ICT national policies in education cannot work solely on their own, they need to be accompanied by the emphasis in the curriculum per subjects. Hence the following discussion gives light on the importance of the development of policies that underpin the use of ICT in schools. Without national policies, the

implementation of ICT in mathematics classrooms would be impossible. To attest to this, Barakabitze et al. (2019) noted poor implementation of ICT policies as one of the major challenges to successful ICT integration. Makoza (2019) defines a national ICT policy as a document that outlines what needs to be done in order to advance the development of ICT. Furthermore, Barakabitze et al. (2019) asserts that, each and every country needs to have a national ICT policy which clearly states the vision and strategic plan that enables the implementation, development and innovation of ICT within the education context.

Poor implementation of ICT policies often leads to poor application of ICT tools in teaching and learning. Jacob, Jegede and Musa (2020) identified poor implementation of national ICT policies as one of the factors that hinder the adoption of ICT in schools. To support the adoption of ICT in schools, Das (2019b) sets out major points that should be included in the education policy:

1. The reflection of new teaching strategies that ICT integration can offer.
2. The policy needs to emphasise and take into consideration the retraining of teachers so that they can successfully integrate ICT in their pedagogical practices.
3. The policy needs to prioritise the provision of infrastructure together with local educational content.
4. In developing countries, the policy needs to state how they will utilise ICT to compensate for the services that they lack in education.

In conclusion, Makoza (2019) notes that the national policy can be in the form of stages, as depicted in Figure 2.1, and it differs according to whether a country is developed or developing.



(Source: Adapted from Makoza, 2019:4)

Figure 2.1: Policy cycle

This following subsection discuss ICT policies and strategic plans for different international countries, African countries and finally, for South African schools.

2.2.2.1 ICT policies and strategic plans for international countries

The following discussion is based on ASEAN[1] countries according to their rank on the ICT index. The aim of this discussion is to gain an insight in how ICT policies are implemented in developed and developing countries internationally.

A. Singapore

Singapore is a developed country, characterised by advanced ICT tools, with successful implementation of ICT tools in schools. According to Machmud, Widiyan and Ramadhani (2021), Singapore is one of the countries with outstanding development in the educational system. Habaradas and Mia (2020) suggests that it is because Singapore consists of various global technology companies, for instance, Google. The Singapore government has invested heavily in the integration of ICT in education (Machmud et al.,2021), as it noted how the use of ICT enriched pedagogical

[1] Association of South East Asian Nations comprising Brunei Darussalam, Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Vietnam

processes (Tou et al., 2020). The government of Singapore prioritised e-education and introduced the first master plan, which aimed at building a foundation through the provision of schools with ICT facilities so that teachers can be trained, while prioritising ICT lessons during curriculum time (Machmud et al., 2021). Machmud et al. (2021) introduced the second master plan (2003 to 2008), introducing set standards on what should be achieved when ICT is integrated, and indicating that ICT had to be used in daily teaching and learning. The third stage aimed at strengthening the competencies and the utility of ICT in the teaching and learning environment, where the self-directed and learning style of students was prioritised, which ensured that learners can learn anywhere using technology (Yuen & Hew, 2018). Lastly, the fourth master plan focused mainly on the development and sustainability of ICT within the school environment with the aim of ensuring that ICT is at the core of education in schools (Machmud et al., 2021).

B. Thailand

Just as in Singapore, the government of Thailand has taken the initiative with the introduction of technology in education sectors in order to equip teachers and learners with technological skills. The government has invested funds through the Ministry of Education of Thailand to support this initiative and further announced the ICT strategy named the master plan, which constitutes different phases (Machmud et al., 2021). The first phase aimed at preparing teachers and learners for ICT implementation by distributing ICT facilities like computers and networks in schools (Yuen & Hew, 2018). This phase also prioritised ICT professional development, designing of the curriculum and acquisition of digital content (Machmud et al.,2021). The second phase, put in place between 2004 and 2006, aimed at ensuring that all learners and teachers have equal access to ICT benefits. In 2007 to 2011, the smart plan was advanced and the national master plan was promoted in 2009 to 2013 to build a nation called Smart Thailand, which is characterised by a society that is technologically literate, not only for the benefit of the economic development, but also for themselves (Wongwuttiwat & Lawanna, 2018). The Ministry of ICT of Thailand outlined objectives of the national master plan as follows:

1. To ensure that there is an increase in everyone's ICT knowledge, and access and improvement in the quality of education,

2. to increase the ranking of the country in the ICT development index, and
3. to integrate ICT industry in the national economy (Machmud et al., 2021).

C. Myanmar

Myanmar is one of the developing countries, however, the government has also supported the adoption of ICT in schools. The government of Myanmar has developed a master plan which came into existence from 2000, with four phases introduced (Htun, 2018). The first master plan is marked by the distribution of ICT infrastructure and the second phase, set between 2006 to 2010, had the goal of accelerating the connection rate (Machmud et al., 2021). The third master plan which aimed at enhancing the competencies for the benefit of the economy, also ensured that the implementation of ICT is incorporated into the curriculum (Nam, Cham & Halili, 2015). This phase also ensured that teachers received ICT training and network connection was also installed in schools (Machmud et al., 2021). At present, Myanmar is in the fourth master plan (Htun, 2018), which is based on the long-term educational plan for the coming 30 years (Machmud et al., 2021).

The following table summarises the strategic plans for Singapore, Thailand and Myanmar, as discussed above.

Table 2.1: Summary of strategic plans for international countries

STRATEGIC PLANS FOR INTERNATIONAL COUNTRIES	
1. Singapore	
1. The first Master plan (1997-2002)	This is the baseline which marked the provision of ICT infrastructure in schools as the aim of providing training in preparation of teachers.
2. The second Master plan (2003-2008)	This stage focused on introducing baseline standards that need to be achieved and ensuring that ICT is fully used during teaching and learning.
3. The third Master plan (2009-2014)	The aim of this stage was to strengthen the utility of ICT by ensuring that students have competences for self-directed learning and they can learn anywhere.
4.The fourth Master plan	This stage offers a vision for future learners while ensuring sustainability of ICT integration.
2. Thailand	
1. The first Master Plan (2000 to 2002)	This stage aimed to prepare teachers and learners for ICT knowledge and distributing ICT facilities in schools.
2. The second Master plan (2004-2006)	This phase ensured that there is equal access and benefits of ICT infrastructure towards all learners and teachers.

STRATEGIC PLANS FOR INTERNATIONAL COUNTRIES	
3. The third Master plan (2007-2011)	This phase aimed at ensuring that all citizens in Thailand are digitally competent and smart.
4. The last Master plan (2009-2013)	The promotion of Smart Thai society.
3. Myanmar	
1. The first Master plan (2000-2005)	Implementation and distribution of ICT facilities.
2. The second Master plan (2006-2010)	Increasing connection rate.
3. The third Master plan (2011-2015)	Enhancing ICT to promote competitiveness of society.
4. Currently	Educational plan for the next 30 years.

(Source: Author's own summary)

2.2.2.2 Policies and strategic plans in African countries

Most of the African countries are developing countries, however, they have also embraced the innovation of ICT and its adoption in the education sector. The following discussion sheds light on how the African countries have supported the adoption of ICT in schools, looking at their policies and strategic plans.

A. Nigeria

Nigeria is one amongst many countries that have encountered challenges in the implementation of ICT in schools; however, the government has taken the initiative to embrace the adoption of ICT in schools. The national policy for ICT in Nigeria stresses the implementation of ICT tools in schools for the major goals:

1. to equip learners with ICT skills and knowledge,
2. to incorporate ICT in mainstreams of education as an aim to produce learners that are ready for the competitive global environment,
3. to build ICT institutions with a wide range of ICT tools, as centres of excellence (FRN, 2001).

This document clearly outlined the need to restructure the education system at all levels so that it aligns and responds positively to the digitalised twenty first century (Jacob et al., 2020).

B. Rwanda

The government of Rwanda has shown commitment in escalating the use of ICT in pedagogical processes so that it can enhance the development of the country. In light of this notion, Muginareza (2021) introduces the two core initiatives to move Rwanda towards the competitive world: firstly, to enable ICT-enhanced classrooms that are conducive for pedagogical processes at all levels of education and secondly, to enable access of all learners and instructors to online material through providing technology devices (Muginareza, 2021). In addition, the conducive environment for teaching and learning involved increased teacher ability to incorporate ICT in the learning environment and competency-based curriculum (Muginareza, 2021). To achieve this ambitious objective, the government set approved strategies and policies that underpin the implementation of ICT in teaching and learning (Mugiraneza, 2021). The following table (Table 2.2) outlines the policies and strategies that underpin ICT integration in Rwanda.

Table 2.2: Policies and strategies of ICT integration in Rwanda

POLICIES
1. The Education Sector Policy 2003
2. The Teacher Development and Management Policy, 2007
3. The ICT in Education Policy, 2016
4. National Strategy for Transformation 2017-2024
5. The Education Sector Strategic Plan 2018/19-2023/24
6. The ICT Sector Strategic Plan 2018-2024
7. The Local Digital Content Promotion Strategy and Implementation Plan 2018-2022
8. The National Skills Development and Employment Promotion Strategy 2019-2024
9. The ICT Hub Strategy 2024
10. The Smart City Rwanda Master Plan

(Source: Adapted from Muginareza, 2021:14)

C. South Africa

To enhance teaching and learning in South Africa, the government supported the idea of implementing ICT in schools. The South African White Paper on e-Education 6 (2004) was developed, which served as the national e-education policy in South Africa (Mathende & Beach, 2022). The aim of the South African White Paper on e-Education

6 was to ensure that every learner across all the bands of education, by 2013 would be ICT capable (DoE, 2004). According to this policy, the key aspects that underpin the adoption of ICT in pedagogy includes access to ICT facilities, capacity building and equity. The policy states that it must be a South African objective to provide equal access and allocation of ICT resources. According to Mathende and Beach (2022), this paper supports instructional processes, curriculum and assessment to enhance the utility of ICT in schools.

South Africa is labelled as a developing country, as it has challenges to provide adequate ICT infrastructure across provinces, resulting in poor implementation of ICT in STEM subjects such as mathematics. The lack of adequate ICT infrastructure widens the gap between South Africa and developed countries, while on the other hand, causing a digital divide within South African provinces (DoE, 2004). The Department emphasises that learners need to have full access to infrastructure for successful e-learning (DoE, 2004) and, in addition, the provision of teacher's development is necessary in order to ensure that teachers are competent and be able to provide effective integration of ICT (DoE, 2004). Following are the initiatives that have supported the integration of ICT in South African schools.

Table 2.3: Strategic ICT plans in South Africa

STRATEGIES
1. White Paper on e-Education 2004
2. South Africa Connect: South African Broadband Policy 2013
3. IJS Digital Transformation Strategy 2017
4. National e-Government Strategy and Roadmap 2017
5. Integrated Justice System (IJS) Digital Transformation Strategy 2017
6. South Africa's National e-Strategy 2017
7. National Integrated ICT Policy White Paper 2016
8. The Third National Skills Development Strategy 2016
9. Professional Development Framework for Digital Learning 2017
10. DTPS Annual Performance Plan 2017-2018

(Source: Adapted from Department of Communications and Digital Technologies, 2020)

2.2.3 The Level of Application of ICT in Education

The preceding discussion outlined the policies that underpin the ICT adoption in different contexts and it described how the governments of different countries have supported the idea of ICT implementation in schools. The following section looks at the level of infusion of ICT tools in schools, as per the expectations from the ICT policies.

2.2.3.1 The level of application of ICT, globally

International countries have equipped classrooms with various technological tools, together with a variety of mathematics software that can be used in mathematics classroom. In Singapore, Machmud et al. (2021) indicated that around 2017, about 84.4% of the people had access to internet and technology is heavily utilised in schools. Furthermore, the Singapore instructional environment has the best and latest digital devices, websites and apps that are used in schools, for instance, 3D printers, iPads and smartphones and iPad apps (Meladi & Awolusi, 2019). In Sweden, there are many technological devices that can be used during instruction and teachers with high intention to use them are able to replace outdated materials with virtual manipulatives (Tossvainen & Faarinen, 2019). For instance, document cameras are utilised to display and discuss learners' solutions, projectors and dynamic programs are used for visual exploration and robots for geometric objects discussions (Tossvainen & Faarinen, 2019). However, it is a cause for concern that many teachers do not use any of these tools. The study carried out by Tossvainen and Faarinen (2019) discovered that the adoption of ICT during mathematics instruction varies and its variation depends on the teacher's choice and ability to use it. Fomunyam (2019) discovered that in African primary and secondary schools, ICT facilities are below standard compared to those of international countries.

Not all international countries have success with the integration of ICT in mathematics classroom. Myanmar is ranked the lowest in the ICT index amongst ASEAN countries and as a result, the education system in Myanmar faces many challenges (Machmud et al., 2021). In 2012 only 5% of schools owned computer laboratories (Machmud et al., 2021). In 2016, the government of Myanmar collaborated with digital companies to enhance the incorporation of technology in schools (Machmud et al., 2021). This collaboration supported teachers by providing them with training so that they have ICT

knowledge and skill to implement it in their pedagogical processes. This collaboration supplied about 3 100 tablets and 186 laptops to teachers. However, countries like Indonesia still suffer from unequal distribution of ICT facilities, which is a major barrier to conducting lessons through technology, while some of the schools lack power supply (Machmud et al., 2021). Amidst the unequal distribution of ICT facilities, there is evidence of ICT incorporation in mathematics in Indonesia. For example, mathematics software like maple, maxima, Geogebra, geometer, sketchpad, cabri, tinkerplots and fathom are used in Indonesia (Mailiza & Fan, 2019).

2.2.3.2 The level of application of ICT tools in African countries

From the above discussion of ICT policy implementation, it is evident that the application of ICT tools is determined by the economic status of the country. Consequently, this affects the integration of ICT in mathematics classrooms. Oke and Fernandes (2020) indicated that beside the immense potential and resources in the African continent, it was discovered that Africa is taking a backseat, currently, and it is not ready for this digital revolution. In disagreement, Jacob et al. (2020) argued that there is growth in the application of ICT in Nigeria and in other African countries. However, Oke and Fernandes (2020) indicated that even if Africa is ready to incorporate ICT, it will take time to catch up with the latest development due to the economic divide. In support of this statement, Fomunyam (2019) attests that African countries are also marked by a huge gap between rural and urban areas. Meladi and Awolusi (2019) also argue that there are concerns that countries in Africa are not making sufficient progress in exploiting the full potential of ICT.

Africa is a very large continent and the application of technology in schools differs from country to country. In countries such as Guinea, Comoros, Burkina Faso, Madagascar and Niger, technology facilities are below standard (Barakabitze et al., 2019). However, Fomunyam (2019) confirmed that other African countries such as Ghana, Mauritius and Botswana are moving steadily towards sustainable economies, hence they are making remarkable progress in ICT integration and Rwanda has managed to provide smart classrooms that enable technology-based teaching and learning by providing computers, software and internet access (Mugiraneza, 2021).

However, Fomunyam (2019) also revealed that there are countries that are still suffering from political issues, resulting in barriers in ICT adoption. The level of

application of ICT in Nigeria is relatively low in secondary schools and many students do not have access to ICT tools, hence they do not use them for their learning (Jacob et al.2020). Jacob et al. (2020) also indicated that the Nigerian curriculum does not align with the acquisition of ICT adoption, and some learners exit high school without access to computers in the classrooms.

2.2.3.3 The level of application of ICT tools in South Africa

South Africa has clear ICT policies that guide how ICT should be implemented in schools. Mathende and Beach (2022) perceive South Africa as the country that rapidly implement ICT in schools for the purpose of digital literacy and economic development. In partnership with other local organisations, the government managed to pilot digital classrooms in schools (Mathende & Beach, 2022). Furthermore, Mathende and Beach (2022) indicated that learners were given tablets to use for learning, and schools received internet connections. Regardless of the fact that this country still struggles with a digital divide, Oke and Fernandes (2020) view South African schools as being ready to tackle obstacles standing in their way of adoption of ICT as they already have computers and tablets, while a robotics programme has already been included in the curriculum.

Amongst all the nine provinces where ICT was implemented and budgeted for, only the Departments of Education from the Western Cape and Gauteng have taken on this innovation and moved forward with it (Mathende & Beach, 2022). In the Western Cape, 5 300 technology-enhanced classrooms were established, aiming at 7 300 by the year 2021 (Mathende & Beach, 2022). The Gauteng Department of Education managed to distribute 64 000 computers to learners and trained about 6 000 teachers on how ICT is integrated in the learning environment (Mathende & Beach, 2022). The provision of tablets, laptops, computers and the internet in schools allow teachers to download and install software that can be used in mathematics. The evidence of the usage of mathematics software in South Africa, as indicated by Ndlovu, Ramdhany, Spangenberg and Govender (2020), include Geogebra, sketchpad, cabri and mathematica. Mokotjo (2020) revealed that in the Free State province, heymath is commonly used, which provides animated lessons that are CAPS aligned.

There are many different ICT devices and tools that are used in the integration of ICT in mathematics instruction, which include devices, software and applications. Table

2.4 below lists these ICT tools (not limited to) and their definition, which is based on how they are used to enhance and support teaching and learning of mathematics.

Table 2.2: ICT devices and tools used in mathematics classroom

TOOLS	EXPLANATION
1. Computer	It is the devise that stores information, like digital textbooks, it can be used for instruction, activities and assessment (Young et al., 2018).
2. Calculator	A devise that is used to find numerical answers quicker (Ndlovu, et al., 2020). There are different types, symbolic, arithmetic, graphing and scientific calculator (Young et al., 2018).
3. Smartboard	A smartboard is used for instruction by teachers, it aids with virtual graphics (Ndlovu et al., 2020).
4. Digital textbooks	These are the textbooks that are in an electronic format, they are available on computers and mobile devices (Asare et al., 2023).
5. Online forums	These are online platforms where learners can discuss and interact either with their peers or their teachers (Wu et al., 2020).
6. Web-based learning	It is an online platform where learners can access learning material, tutorials and activities (Hu, 2020).
7. Internet	For searching information and other resources for teaching and learning (Barakabitze et al., 2019).
8. Mathematical software Geogebra	Geogebra is a software that enhances mathematics teaching and learning in geometry, statistics and algebra (Tamam & Dasari, 2020).

(Source: Author's own design)

2.2.4 How ICT is Integrated in the Mathematics Classroom

The are two ways in which ICT tools can be applied in mathematics instruction, either to do activities offered and engage with other learners and instructors, or to use during teaching and learning to facilitate understanding of the content. Young et al. (2018) describe these as computer-enhanced instruction and instruction based on computer. For instruction based on computer, tools like simulation software can be used in the classroom to create visuals where learners can clearly understand mathematical concepts (Sukowati, Wulandari & Priyanto, 2019). For computer-enhanced instruction, learners work in collaboration or individually to solve problems using digital tools like graphic calculators, spreadsheets while allowing productive time in solving problems (Das, 2019a). Young et al. (2018) indicated that the affordances of calculators in the classroom cannot be denied, but mathematics teachers always debate about when to use them. For example, Meladi and Awolusi (2019) opposed the use of the calculator as their study revealed that mathematics and science teachers are against the use of

digital devices since it can easily solve problems for learners. In support of this notion, Marbán and Malenga (2019) argued that learners need to display their understanding of mathematics without being assisted by mathematical tools.

2.2.5 The Use of ICT in Different Mathematics Content Areas

In the Senior Phase, Grades 7 To 9, five mathematic content areas are stipulated by CAPS document for mathematics. These content areas include numbers, operations and relationships, patterns, operations and algebra, space and shape, measurement and data handling (DBE, 2011). To teach the different topics of these mathematical content areas, Das (2019a) indicated that ICT tools are very useful and beneficial. The following table gives a brief of how ICT can be used in different content areas.

Table 2.3: Application of ICT tools in different mathematics content areas

MATHEMATICS CONTENT AREAS	APPLICATION OF ICT TOOLS
1.Numbers, Operations and Relationships	Mathematics software can be used for addition and subtraction of integers (Verzosa, De Las Peñas, Aberin & Garces, 2018).
2.Patterns, Functions and Algebra	ICT tools can be applied in algebra to determine the equation of a straight line, while the graph is also drawn (Tamam & Dasari, 2020).
3.Space and Shape (Geometry)	In geometry, Geogebra software can be used to visualise 2 and 3-dimentional objects (Azizah et al., 2021).
4. Measurement	Measurement works well with geometry where the sides of the 2 and 3-D objects can be identified using mathematics software (Das, 2019a).
5. Data Handling	In data handling, ICT tools like Geogebra can be used to determine the variables of statistics, like a mode, median and mean (Tamam & Dasari, 2020).

(Source: Author's own design)

2.2.6 The Application of Mathematical Software

The uniqueness of different subjects highlights the necessity to develop pedagogical strategies that are compatible with that particular subject, hence different software is used for mathematics. There is a range of software that can be used to enhance mathematics teaching and learning such as, Geogebra, mathematica, algebra solver software, sympy algebra software, mathspad, sketchpad and inkscape (Dhakal, 2018). The concept of Geogebra software is presented in the following section which describes how it is applied during the teaching and learning of different mathematics topics.

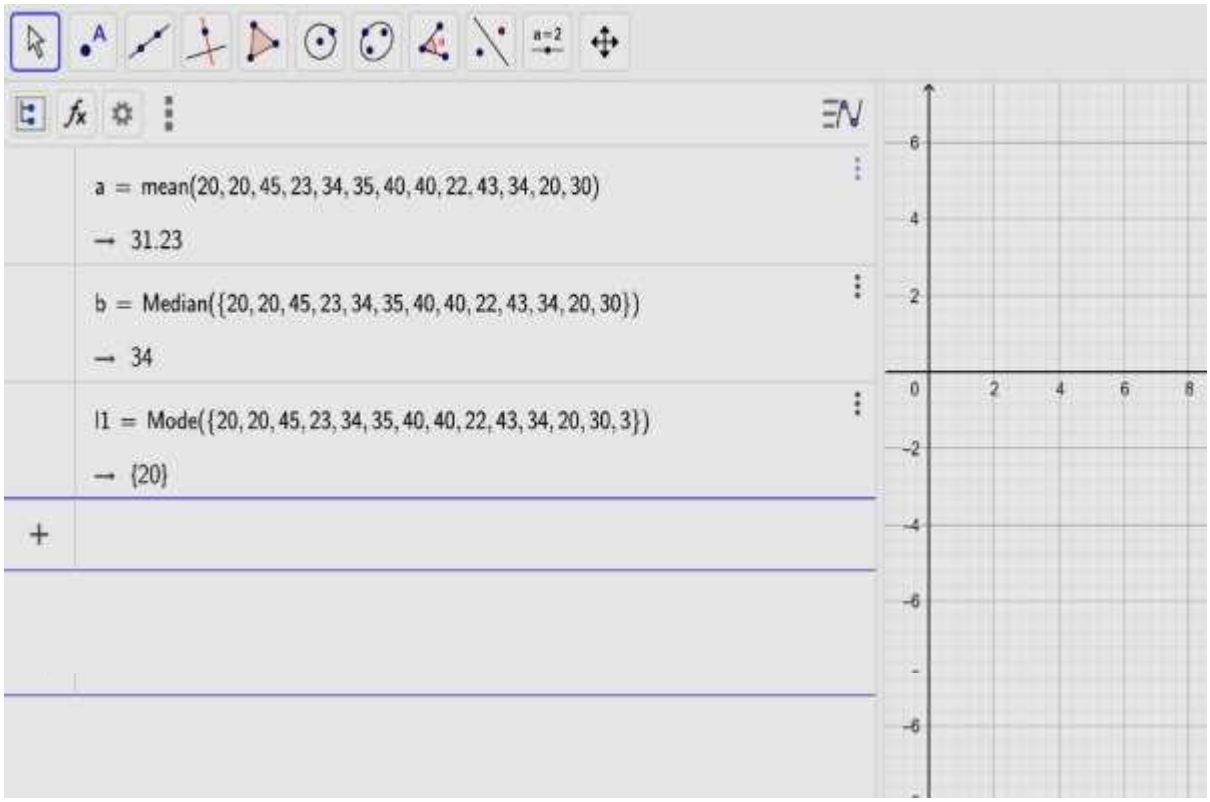
2.2.6.1 Geogebra software

Geogebra software, mostly utilised in mathematics instruction, is highly recommended as it is beneficial to both instructors and learners (Dockendorff & Solar, 2017). It is easily accessible and it is easy to use (Saputra & Fahrizal, 2019). It has been translated into 73 different languages and any person can download it onto their personal devices (Tamam & Dasari, 2020). Geogebra enhances mathematics teaching and learning in geometry, statistics and algebra (Tamam & Dasari, 2020) as well as in calculus (Zulnaidi, Oktavika & Hidayat, 2020).

This software is used to visualise, construct and explore mathematics content (Tamam & Dasari, 2020). It enhances learners' mathematics abilities, for instance, problem solving and reasoning abilities (Tamam & Dasari, 2020). In addition, Zulnaidi et al. (2020) posit that, mathematical procedures and concepts are easily demonstrated, resulting in understanding of various mathematical concepts. Moreover, Zulnaidi et al. (2020) argue that Geogebra is time consuming; however, it enhances learner's active engagement as it can be used in the teaching of different mathematics content.

A. Application in statistics

Data handling is one of the content areas of the Grade 7 mathematics curriculum, which includes the calculation of different parameters in order to analyse data collected. According to Tamam and Dasari (2020), Geogebra can be utilised in statistics to calculate the mean, median and mode of the data set. In practice, this can be done by entering the required parameter and the data set in the input bar menu and press enter (Tamam & Dasari, 2020). The following diagram illustrates the results if the steps are correctly followed.

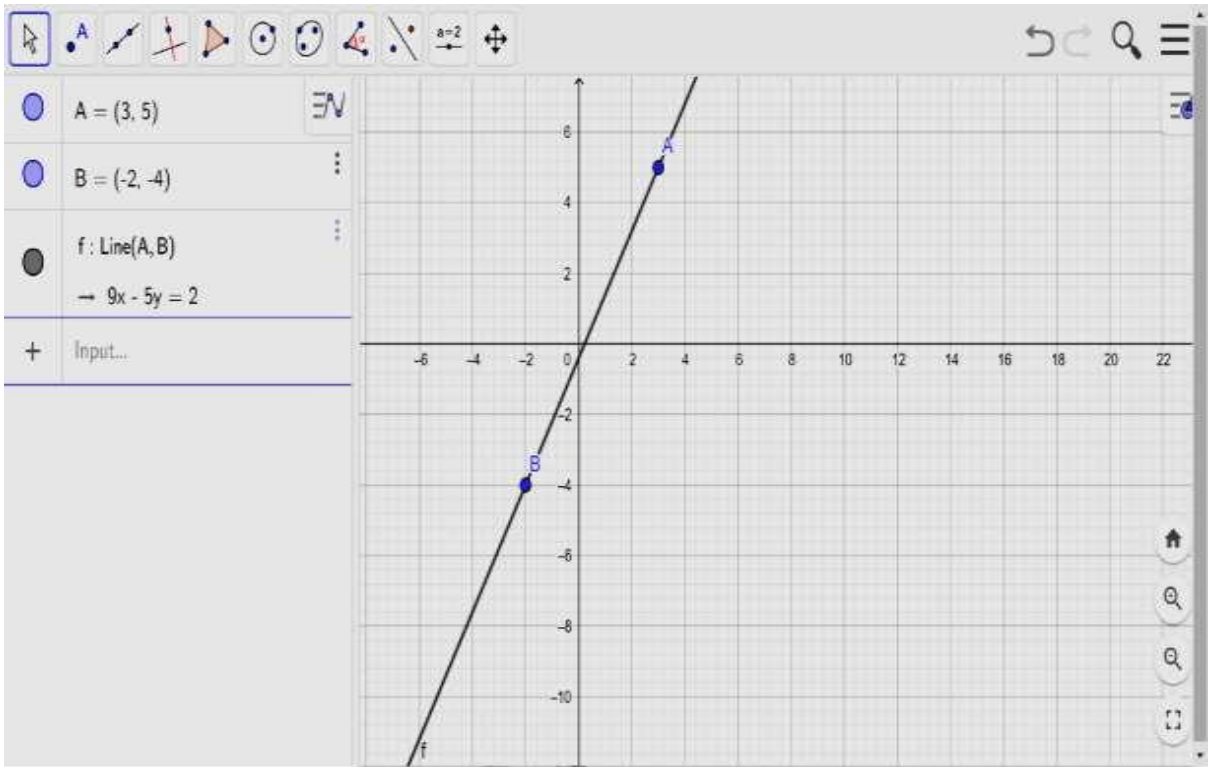


(Source: Adapted from Tamam & Dasari, 2020:3)

Figure 2.2: Application of Geogebra in statistics

B. Application in algebra

Most learners struggle with determining the equation of the graph, together with drawing of different graphs in mathematics. Using Geogebra software, learners can simultaneously determine the equation of the straight line and also draw the straight line (Tamam & Dasari, 2020). In practice, according to Tamam and Dasari (2020), this can be done by inserting the given pair of coordinates (A and B), press enter, then type line AB, and press enter again, and the following results demonstrated by Figure 2.3 will appear.

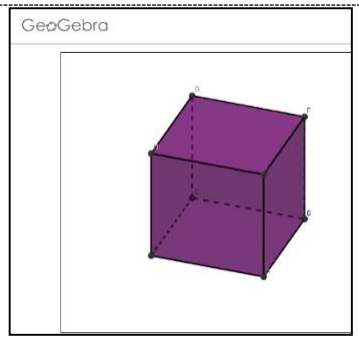


(Source: Adapted from Tamam & Dasari, 2020:4)

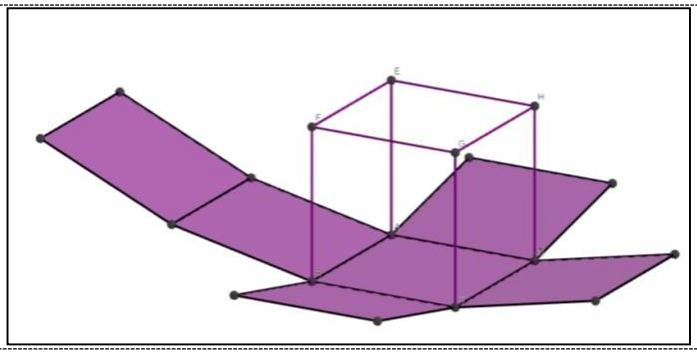
Figure 2.3: Application of Geogebra in Algebra

C. Application of Geogebra in geometry

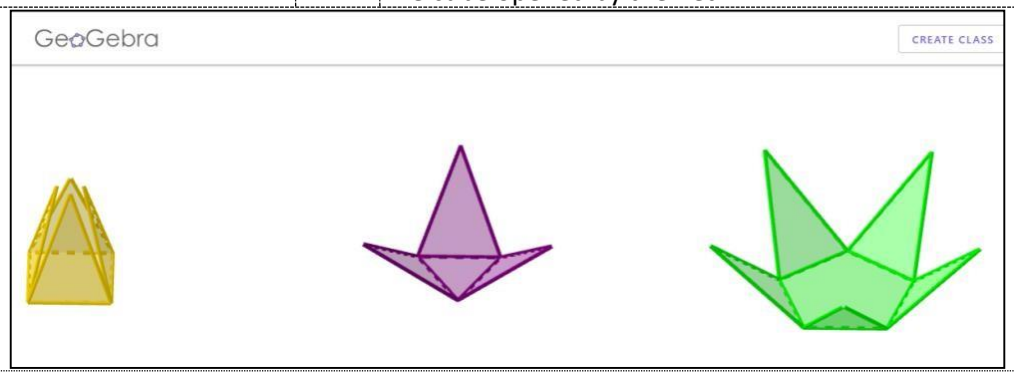
In mathematics, Grade 7 learners learn about 3-Dimentional (3-D) objects and 2-Dimentional (2-D) shapes, which fall under the content area of geometry. Geometry is the study of space and shape, dependent on visualising skills, which many learners struggle to master (Dahal, Shrestha & Pant, 2020). The CAPS document clearly states that learners are also expected to be able to identify and draw the nets of 3-D objects as one of the objectives to be achieved at the end of the lesson (DBE, 2011). This goal can be achieved through the use of mathematics software, where learners are able to clearly visualise the nets of the 3-D objects (Azizah et al., 2021). Figure 2.4 demonstrates the cube and its net, and the other nets of different 3-D objects.



Cube



The cube opened by the net



N-sided pyramid net

(Source: Adapted from Azizah et al., 2021:5)

Figure 2.4: Application of Geogebra in geometry (3-D objects)

2.3.7 Benefits of ICT Integration in the Mathematics Classroom

The preceding topic outlined how teachers integrate technological tools, devices and software in mathematics instruction. The use of these tools can have either a positive or a negative impact in mathematics teaching and learning. This brings us to the discussion of the benefits resulting from ICT incorporation in mathematics teaching and learning.

2.2.7.1 ICT facilitates the understanding of mathematics concepts

Visualisation is one of the crucial skills in mathematics that learners fail to develop, hence mathematics software is used to clearly visualise the objects, while facilitating the understanding of mathematics concepts. Zulnaidi et al. (2020) argue that the use of software like Geogebra enhances the understanding of various concepts in different content areas in mathematics, including algebra, geometry, calculus and statistics. Geometry, in its nature, requires the ability to visualise objects for the understanding of this concept (Dahal et al., 2020). Learners struggle to clearly visualise the objects, hence creating a barrier in learning. In transformation geometry where rotations,

translations and reflections are applied, learners struggle to understand these concepts when drawn on the board, unless if they are viewed in mathematics software where they can be manipulated (Dahal et al., 2020). Furthermore, Henderson (2020) argues that the use ICT tools does not only assist in understanding concepts, but it also holds the power of mathematical knowledge retention.

2.2.7.2 ICT encourages collaboration

With the integration of ICT in teaching and learning of mathematics, learners are able to engage in online forums and collaborate with other learners. A learner-centred approach is promoted, while learners are also able to access a range of learning materials (Das, 2019a). In this way, there is information sharing, learners get involved in online tasks and peer feedback is promoted resulting in learning (Henderson, 2020). Engelbrecht, Llinares and Borba (2020) argue that collaboration acts as a medium to facilitate mathematical knowledge construction. However, while collaboration is encouraged, the integration of technology in the learning environment encourages individual learning (Das, 2019a).

2.2.7.3 ICT facilitates engagement

The teaching and learning of mathematics require a learner-centred approach encouraging active participation of learners. Henderson (2020) indicated that the use of ICT encourages active participation during the lessons in the classroom, which is not easy to achieve during traditional learning environment. Dahal et al. (2020) note that mathematics software allows learners to create and transform objects, in this way they stop being passive and become active learners. Raja and Nagasubramani (2018) suggest that learners prefer visuals than just reading words since it helps to promote their thinking. Therefore, through the use of mathematics software, learners' interest is aroused (Dahal et al., 2020), and they become eager to learn (Das, 2019a). In addition, Ndlovu et al. (2020) believe that ICT integration in mathematics serves as a motivational value, while developing a positive attitude which reinforces learners' attitude towards mathematics.

2.2.7.4 ICT develops learners' problem solving and critical thinking skills

Mathematics is known for developing learners' logical and critical thinking skills which influences decision making in problem solving. Dhakal (2018) has identified mathematics software as the answer to the quest of promoting problem solving

strategies. If learners lack problem solving abilities, according to Abdullahi and Sirajo (2022), it contributes to barriers to learning mathematics. In addition, technology assists in the development of problem-solving skills through interactive learning in forums, promotion of deeper understanding of the problem and allowing space for individual thinking (Abdullahi & Sirajo, 2022). The success of problem-solving skills, is proof that thinking skills has been acquired (Das, 2019a), which is also advanced through the integration of ICT devices and tools (Tamam & Dasari, 2020).

2.2.7.5 ICT supports different learning styles

Mathematics instruction requires the use different strategies to accommodate and support all learners at different cognitive levels. The incorporation of ICT is one of the strategies. The Department emphasises, prioritises and promote the idea of the importance of inclusivity in schools (DBE, 2011). Therefore, Meladi and Awolusi (2019) advocate that the incorporation of ICT in the classroom supports the practice of inclusivity. In addition, Das (2019a) attests that learners have different learning styles and abilities and technology in mathematics classroom is able to accommodate a variety of learners' needs since it provides a wider range of delivery methods by teachers. For resource-based learning, information technologies act as a source of information, while also acting as an additional learning material during teaching and learning of mathematics (Das, 2019). Furthermore, the use of a wider range of ICT tools in the mathematics classroom results in a positive effect on improving the achievement of learners (Ishaq et al., 2020).

2.2.8 Challenges Experienced in the Mathematics Classroom

There are many benefits of ICT integration during mathematics instruction, however, there are also obstacles that hinder the process of the integration of ICT in mathematics teaching and learning. The studies conducted by Ahmed, Abdelraheem, Al-Shenadi, and Al Aghbari, (2019); Al-Mamary (2022) and Kaur (2023) revealed that educational instructors are eager to integrate ICT in their instructional process, but they encounter many barriers. The following section unpacks challenges that teachers face when using technology in the teaching of mathematics. Globally, in African countries, also in South Africa, these challenges are common.

2.2.8.1 Lack of mathematical technology-based learning resources

Teachers place more emphasis on the use of technology in general, while placing less emphasis on incorporation of ICT tools in mathematics instruction due to the lack of mathematical technology-based resources. Mokotjo (2020) indicated that teachers prefer to use ICT tools to teach mathematics rather than enhancing mathematics instruction through the use of ICT software. The success of ICT incorporation in mathematics instruction is clearly visible through the use mathematically based software (Das, 2019a), for instance, Geogebra. However, there is a lack of these mathematical applications for certain mathematics topics (Muhazir & Retnawati, 2020). In the study conducted by Muhazir and Retnawati (2020), mathematics teachers who were participants, pointed out that they are aware of the Geogebra application which is used for geometry, but they do not know any software that will cater for topics such as fractions.

2.2.8.2 Level of skills of integrating ICT in mathematics pedagogy

The availability of ICT devices does not guarantee that teachers will integrate them during teaching and learning, as they require knowledge and skills of ICT integration in mathematics. Muhazir and Retnawati (2020) raised a concern about teachers lacking skills of integrating ICT, especially in the mathematics classroom, and as a result, teachers struggle to implement ICT tools in the mathematics classroom. Pultoo et al. (2020) also argued that in order for teachers to be confident in integrating ICT in the classroom, they need adequate skills. Teacher's unpreparedness and hesitation towards ICT integration in education due to lack of ICT knowledge, plays a huge role in slowly attaining its objectives in teaching and learning process (Hero, 2020).

2.2.8.3 Integration of ICT in mathematics instruction is time consuming

A successful technology-enhanced mathematics lesson is characterised by proper planning and preparation, otherwise, it can lead to more time being consumed in the classroom. Das (2019a) argues that ICT integration does not only waste time in the classroom, but the preparation of mathematics lessons through electronic content, is also time consuming. Consequently, teachers have to deal with mathematics content and ICT incorporation-based challenges, simultaneously (Das 2019a). According to the CAPS document, there is time allocation for each and every subject per week (DBE, 2011) and the concern is whether teachers are able to keep up with the

mathematics syllabus if they integrate ICT in the classroom. Viberg, Mavroudi, Balter and Khalil (2020) argue that ICT integration in mathematics pedagogy is time consuming because if teachers want to integrate ICT, for instance a mathematics software, it is challenging because a teacher will have to first demonstrate to the learners how to use the software, which is time consuming. In support of this statement, Muhazir and Retnawati (2020) attest that learners also need to understand how the mathematical software works before it can be utilised in the classroom.

2.2.8.4 Inadequate ICT-based training related to mathematics instruction

The gap still exists in ICT incorporation in mathematics instruction which is caused by the inadequate training received by mathematics teachers. Muhazir and Retnawati (2020) revealed that teachers do not receive training on the use of the software in mathematics instruction. Das (2019a) reported that teachers, in many cases, are unaware of the type of ICT knowledge that is available, also how to incorporate it in mathematics teaching environment. In the study conducted by Muhazir and Retnawati (2020), teachers preferred using readily available YouTube videos because they lack skills to create their own mathematically based content, which is due to the lack of skills. In conclusion, Hero (2020) recommended that teachers require professional development and training through programmes so that they can obtain the knowledge and skills necessary to efficiently utilise technology resources during instruction.

2.2.8.5 External or contextual factors

Education White Paper 6 outlined that there would be factors likely to cause a digital divide amongst different South African education contexts (DoE, 2004). One of these are the contextual factors that also directly affect ICT incorporation in the mathematics classroom. These challenges include inadequate ICT infrastructure, high cost of ICT tools and resources, insufficient funds for ICT tools, poor implementation of ICT policy and unstable power supply (Bayode, Poll & Ramphal, 2019). Singhavi and Basargekar (2019) conclude that the barriers that are evident in hindering the incorporation of ICT in education sector are mostly extrinsic factors (related to the availability of resources, time, support system, training facilities, among other factors), compared to intrinsic factors (such as attitudes, beliefs, practices and the resistance of the teachers).

2.2.9 Teachers' Perception on ICT Integration in Mathematics Classroom

Teachers' perceptions, opinions and experiences are worth noting because they are the key stakeholders in delivering lessons and ensuring mathematics achievement and improvement. The benefits and challenges of ICT integration in the mathematics classroom has been discussed and the concern remains if they have any influence on how teachers perceive the use of ICT tools in mathematics pedagogy. Ndlovu et al. (2020) believe that teachers' attitudes and perceptions of ICT integration influences their intention to incorporate ICT in mathematics instruction. As a result, there is a necessity to understand teachers' beliefs and the use of ICT tools in mathematics instruction since it prompts the need to investigate the effects it has on mathematics pedagogy (Kiru, 2018). Ardiç (2020) notes the importance of understanding teachers' views since it will promote effective integration of ICT in mathematics teaching and learning. Murithi and Yoo (2021) argued that if the teachers' attitude towards the integration of ICT is not addressed, the desired results will never be achieved. How instructors perceive ICT incorporation in mathematics teaching and learning globally, in Africa and in South Africa is discussed in the subsequent sections.

2.2.9.1 Teachers' perceptions of ICT integration globally

Most international mathematics teachers have shown extensive use of ICT tools in mathematics teaching and learning; however, they perceive ICT integration differently. In Turkey, teachers expressed a positive attitude on the use of ICT in mathematics instruction, however, due to the lack of mathematical software knowledge (Geogebra and mathematica), they perceive ICT as inappropriate for mathematics instruction and it offers no benefits (Ardiç, 2020). In contrast, teachers from Nepal praised mathematics software (Geogebra and mathematica) as they believe that they are very helpful since the focus of problem-solving shifts from spending time on tiresome computational calculations to interpretation of answers (Dhakal, 2018). A study done in Japan revealed that mathematics teachers prefer utilising technology over talk-and-chalk methods but are very aware that ICT tools are not compatible with all mathematics content (Dorji & Ishii, 2023). Furthermore, Dorji and Ishii (2023) indicated that teachers in Japan perceive ICT incorporation in mathematics content as an improved instructional material since it allows extended discussion beyond school contact hours. Through the use of google classroom, learners and teachers are able

to interact while learners are at home, to do reflection on the lesson of the day (Dorji & Ishii, 2023).

2.2.9.2 Teachers' perceptions of ICT integration in Africa

African countries are still experiencing many challenges related to ICT integration in education and in mathematics teaching and learning. These countries are characterised by insufficient progress in exploiting the full potential of ICT (Meladi & Awolusi, 2019). However, this cannot be a deciding factor on how African mathematics teachers perceive the incorporation of ICT in the classroom. Uwineza, Uworwabayeho and Yokoyama (2023) conducted a study in Rwanda and found that teachers perceive mathematics software as useful because learners' mathematical concept understanding is improved, together with learners' interest. In correspondence, teachers in Nigeria also perceive ICT utility in mathematics as beneficial since it improves performance and achievement (Kiapene, 2022). While teachers in other countries perceived technology as the way of promoting a learner-centred approach, teachers in Ghana differed in opinion. Teachers in Ghana still use a teacher-centred approach with the belief that a learner-centred approach leads to misconceptions and unanswered questions (Mensah & Agyei, 2019). Furthermore, teachers worry about the omission of procedural steps with the use of mathematical software (Mensah & Agyei, 2019). Some teachers perceive ICT tools as unnecessary with the belief that old methods of teaching still work perfectly, hence there is no need to incorporate ICT in mathematics (Mensah & Agyei, 2019). In contrast with the negative comments on how teachers in Ghana perceive ICT integration in mathematics pedagogy, some teachers were positive about ICT integration. They believe that mathematics software is useful when it comes to visualisation of objects because not all learners are able to clearly visualise objects drawn by teachers on the board, more especially 3-D objects (Mensah & Agyei, 2019).

2.2.9.3 Teachers' perceptions of ICT integration in South Africa

South Africa is also clouded by many challenges regarding technology incorporation in mathematics instruction; however, teachers who have access to ICT tools presented different perceptions based on their experiences. Ndlovu et al. (2020) posit that South African mathematics teachers perceive ICT incorporation in mathematics as beneficial, because of its creation of enthusiasm, promotion of mathematical thinking

skills and enhancement of mathematical content understanding through the use of Geogebra software. In support of this notion, Mokotjo and Mokhele-Makgalwa (2021) indicated that teachers perceive Geogebra software as a tool that is relevant to South African curriculum. In addition, Umugiraneza, Bansilal and North (2018) attest that teachers have a positive attitude towards the utility of ICT in mathematics, claiming that it facilitates mathematics pedagogy. In contrast, Meladi and Awolusi (2019) revealed that teachers who teach mathematics are against the use of ICT because they worry that technology tools will easily solve problems for learners. In the South African context, teachers perceive mathematics as a practical subject, hence, learners need to be involved in lessons through practising on the board (Ndlovu et al., 2020).

2.3 THEORETICAL FRAMEWORK

As indicated in Chapter 1, any research needs a theoretical framework which serves as a review of existing theories that aid in the direction of the research investigation (Cohen et al., 2018). The theoretical framework serves as a point of reference, following is the discussion of the theory that underpins this study.

2.3.1 The Origin and History of the Theory

Through research studies, the introduction and adoption of technology resulted in the emergence of several competing models, which constitute different acceptance determinants. Venkatesh et al. (2003) empirically compared these models and theories and invented a unified model called a Unified theory of Acceptance and Use of Technology (UTAUT). The development of the UTAUT was evidently supported by the discovery of the common significant elements among the previously established models. The following table (Table 2.4) summarises the theories and models that led to the development of the UTAUT.

Table 2.4: Theories and models of technology acceptance

Theory	Constructs	The belief about the System
1.Theory of reasoned Action (TRA)	Attitude towards behaviour	It depends on how one feels about the intended system.
	Subjective norm	How important and surrounding people perceive the use of the system.
	Perceived usefulness	An individual believes utilising a system will improve their job.

Theory	Constructs	The belief about the System
2.Technology Acceptance model (TAM)	Perceived ease of use	A system is used because it is believed to be free of effort.
	Subjective norm	With reference to TRA
3.Motivational Model (MM)	Extrinsic motivation	External factors motivate an individual to perform a job, such as a job promotion.
	Intrinsic motivation	An individual simply uses a system without any reinforcement.
4.Theory of Planned Behaviour (TPB)	Attitude towards behaviour	With reference to TRA.
	Subjective norm	With reference to TRA.
	Perceived behavioural control	It is based on how easy or difficult it is to use a system.
5.Combined TAM and TPD (C-TAM-TPB)	Attitude towards behaviour	With reference to TRA and TPB
	Subjective norm	With reference to TRA and TPB
	Perceived behavioural control	With reference to TRA and TPB
	Perceived usefulness	With reference to TAM
6.Model of PC Utilisation (MPCU)	Job fit	Belief that the system will improve their job performance.
	Complexity	The level of difficulty towards using the system.
	Long term consequences	Consideration of future outcomes.
	Affect towards use	It is based on how one feels about the system.
	Social factors	The use of the system depends on the certain group or cultural norms.
	Facilitating conditions	Factors that make it easy to use the system.
7.Innovation Diffusion Theory	Relative advantage	It is based on the advantages that are brought by the system, that are better than its precursor.
	Ease of use	The difficulty to utilise the system.
	Image	The ability of the system to enhance an individual's image.
	Visibility	Others in the institution are seen using the system.
	Compatibility	The system aligns with the existing norms, needs and past experiences.
	Results demonstrability	Based on the results of the system being observable and communicable.
	Voluntariness of use	One uses a system because it is not mandatory, but voluntary.
8.Social Cognitive Theory (SCT)	Outcome expectations performance	One uses a system based on the expected outcomes in relation to the job.

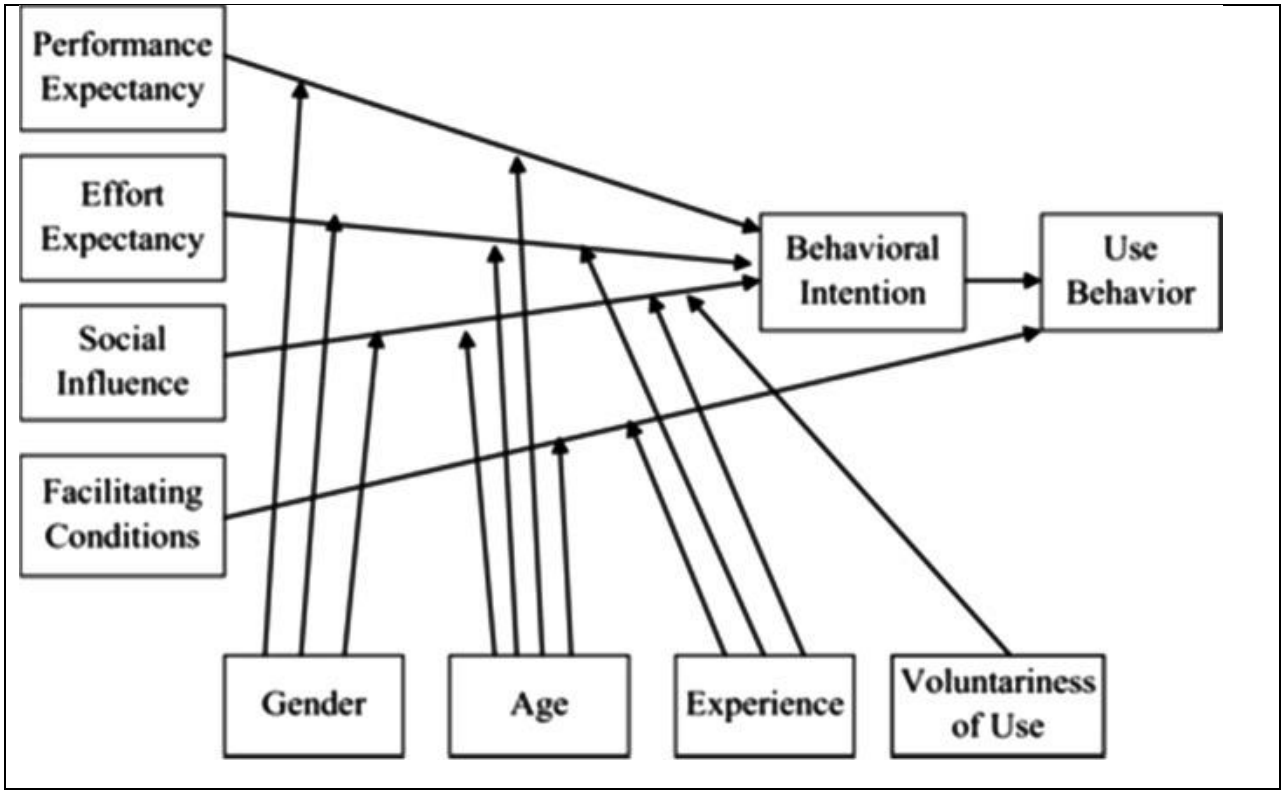
Theory	Constructs	The belief about the System
	Outcome expectancy personal	One uses a system because it yields personal outcomes.
	Self-efficacy	It is based on how one judges themselves towards using the system.
	Affect	The consideration is based on liking the system.
	Anxiety	Emotional reactions are being evoked when using the system.

(Source: Adapted from: Venkatesh et al., 2003:428-432)

2.3.2 Unified Theory of Acceptance and Use of Technology (UTAUT)

The unified theory resulted from the comparison of the eight theories and models of technology acceptance and use (Venkatesh et al., 2003). Performance expectancy, effort expectancy, social influence and facilitating conditions are the key determinants that characterises this theory (Venkatesh et al., 2003). The figure below (Figure 2.5) displays the relationship between the behaviour intention and the core determinants of the unified model (UTAUT). The hypothesis of this theory states that performance expectancy, effort expectancy and social influence directly influence the intention of behaviour while facilitating conditions directly influence the actual usage of technology (Venkatesh et al., 2003). In addition, gender, age, experience and voluntariness are moderators that influence the behavioural intention through the key determinants (Venkatesh et al., 2003).

Alshammari (2021) modified this theory for the education context and included mobility as one of the aspects to predict behaviour intention towards the acceptance and utility of virtual classrooms. Furthermore, Oke and Fernandes (2020) employed UTAUT to assess and evaluate the education sector's readiness for the drastic changes that come with technology. Putloo et al. (2020) employed this model to understand teachers' approval and use of technology-enhanced classrooms and Liebenberg et al. (2018) applied unified theory to investigate the approval of ICT by South African students. While Abbad (2021) applied the UTAUT model to investigate students' behaviour with the use of e-education in developing counties, Graham et al. (2020) applied the UTAUT model to explore factors influencing educators to integrate ICT in their mathematics classrooms. In this study, UTAUT was used to determine Grade 7 teachers' perspectives on the implementation of ICT in mathematics classrooms based on the core determinants of the unified theory.



(Source: Adapted from Venkatesh et al., 2003:447)

Figure 2.5: Unified theory model (UTAUT)

Performance expectancy: Venkatesh et al. (2003) proved that performance expectancy is the most influential predictor of behavioural intention amongst them all, whether in a mandatory or voluntary context. Venkatesh et al. (2003) described performance expectancy as the belief one has about the system in terms of assisting in improving and advancing work performance. The key aspects of this determinant involve perceived usefulness, extrinsic motivation, job fit, relative advantage and outcome expectation (Venkatesh et al., 2003). Performance expectancy is very useful in the adoption of a system since an individual can assess whether it can assist in completing tasks quickly, increase productivity, enhance effectiveness and improve quality of work. This study aimed to utilise performance expectancy to understand the benefits of integrating ICT in Grade 7 classrooms. Performance expectancy also assisted in determining how educators perceive the utilisation and adoption of technology in the classroom.

Effort expectancy: This is defined as the extent to which someone considers how easy it is to use a system (Venkatesh et al., 2003). This implies that, before an individual considers using a new system, they should assess the effort the system requires, the complexity that comes with the system and if they clearly understand

how the system works. In this study, the focus was on exploring teachers' experiences based on the integration of ICT in schools.

Social influence: Social influence is the degree in which an individual's use of the new system depends on the perceptions of important people around them (Venkatesh et al., 2003). This implies that individuals use a system, being influenced by the views of their supervisors regarding the system. It also depends on how other co-workers perceive that system. In a mandated context the constructs of social influence become significant while none of them is significant in a voluntary situation (Venkatesh et al., 2003). In an educational context, this implies that an individual's use of ICT is based on the supervisor's support or assistance to use the system. Social influence, in this study, was used to determine social factors that impact the acceptance and incorporation of technology in Grade 7 mathematics classrooms.

Favourable conditions: This is the final determinant of the unified theory. Its definition stems from one's belief about the availability of compatible infrastructure in an organisation that supports the utility of a certain system (Venkatesh et al., 2003). Before a person utilises the system, they consider the control they have over the use of the system and whether they have appropriate and sufficient resources to adopt the system. They also consider if any guidance and assistance is provided regarding the system. In this study, favourable conditions were used to identify the availability of necessary resources (teachers' ICT knowledge, infrastructure, skills and support) that facilitate the integration of ICT.

All the determinants discussed above are presented in Table 2.9.

Table 2.5: Summary of the determinants of user acceptance and usage behaviour

DETERMINANT	DEFINITION	KEY CONSTRUCTS
1. Performance expectancy	The belief one has about the system in terms of assisting them in improving and advancing their work performance. (Venkatesh et al., 2003)	➢ Perceived usefulness ➢ Extrinsic motivation ➢ Job fit ➢ Relative advantage ➢ Outcome expectations
2. Effort expectancy	Effort expectancy is defined based on how easy it is to use a system. (Venkatesh et al., 2003)	➢ Perceived ease of use ➢ Complexity ➢ Ease of use
3. Social influence	Social influence is the degree in which an individual's usage of the	➢ Subjective norm ➢ Social factors

DETERMINANT	DEFINITION	KEY CONSTRUCTS
	new system depends on the perceptions of important people around them (Venkatesh et al., 2003).	➢ Image
4. Facilitating conditions	It is described as a belief one has in the system based on the existence of necessary resources which are compatible with someone's job. (Venkatesh et al., 2003)	➢ Perceived behavioural control ➢ Facilitating conditions ➢ Compatibility

(Source: Adapted from: Venkatesh et al., 2003:448-454).

2.3.3 The Contribution of the UTAUT Model in Education Sector

The use of the UTAUT model has been evident in several studies where different authors have shown the importance of this theoretical model in the approval of technology in the education sector. Abbad (2021) believes that the UTAUT model serves as a valuable tool to give clarity on factors that drive e-education acceptance, thus enabling curriculum designers and decision makers to decide on how to facilitate the implementation of technology in the education sector. In alignment with this statement, Alshammari (2021) believes that the use of UTAUT is able to assist policy makers and practitioners acquire a deeper understanding of the factors affecting attitude towards and use of virtual classrooms, hence leading to making better decisions on how to influence teachers to accept this system. Oke and Fernandes (2020) conducted a study which drew upon the unified theory to explore how stakeholders in the education sector position and utilise the idea of the 4IR in the body of education.

The adoption of the UTAUT model in this study explored the readiness and the preparedness of the education sector for the acceptance of ICT. The implication being that the UTAUT model is able to predict whether stakeholders are ready and prepared to accept technology. Abbad (2021) further explained that this theoretical model is also able to explain the students' behaviour regarding the use of e-education. Almaiah, Almari and Al-Rhmi (2019) also conducted a study to explain students' acceptance of technology in higher education. Alshammari (2021) argued that it is through the UTAUT model that decision makers are able to improve the body of e-learning, based on its impact and its usage.

2.3.4 A Review of Research on the UTAUT Model

Alshammari (2021) carried out a study and applied the unified theory to explore factors that influence educators in the acceptance and use of virtual classrooms. The study revealed that only two determinants, performance expectancy and effort expectancy, were able to determine the behavioural intention of the staff to use virtual classrooms. Social influence together with facilitating conditions proved to be insignificant determinants of intention to accept and utilise virtual classrooms. The behaviour intention proved to have a positive impact on the actual use of virtual classroom. This result is consistent with the studies conducted by Venkatesh et al., (2003), Sultana (2020) and Alshehri, Rutter and Smith (2019). The significance of the behaviour intention on actual use implied that if teachers do have an intention to use virtual classrooms, then it would lead them to actually use the virtual classrooms (Alshammari, 2021).

Pultoo et al. (2020) used the term classe21 to brand the technology-enhanced classroom in Mauritius and applied UTAUT to determine factors impacting the approval of classe21 by teachers. This study gave other stakeholders and policymakers' insight into understanding teachers' perspective on the adoption of ICT. The study revealed that only three key constructs (performance expectancy, social influence and facilitating conditions) indicated the significance of behavioural intention, in which performance expectancy has shown to have the highest positive influence. Most teachers perceive that technology-enhanced classroom could improve their job performance and assist during teaching and learning (Pultoo et al., 2020). Effort expectancy revealed no significant relation with behavioural intention. The results were not in accordance with the results of the research conducted by Chao (2019) as the effort expectancy had a significant effect on the behavioural intention.

Liebenberg et al. (2018) assert that university students are called digital natives; however, one should question their readiness and preparedness to accept technology integration in their studies. A study was conducted to explore South African students' intention towards the use of technology tools. A questionnaire was created based on UTAUT constructs. The findings revealed that performance expectancy, effort expectancy and facilitating conditions positively affected the intention to use technological devices, with performance expectancy being the dominant determinant

of intention towards behaviour. According to Liebenberg et al. (2018), this indicates that if students hold the belief that using technology could improve their academic performance, they would definitely accept the use of technology. Effort expectancy indicated a significant role, which is in contrast to the findings of the study conducted in Mauritius by Pultoo et al., (2020).

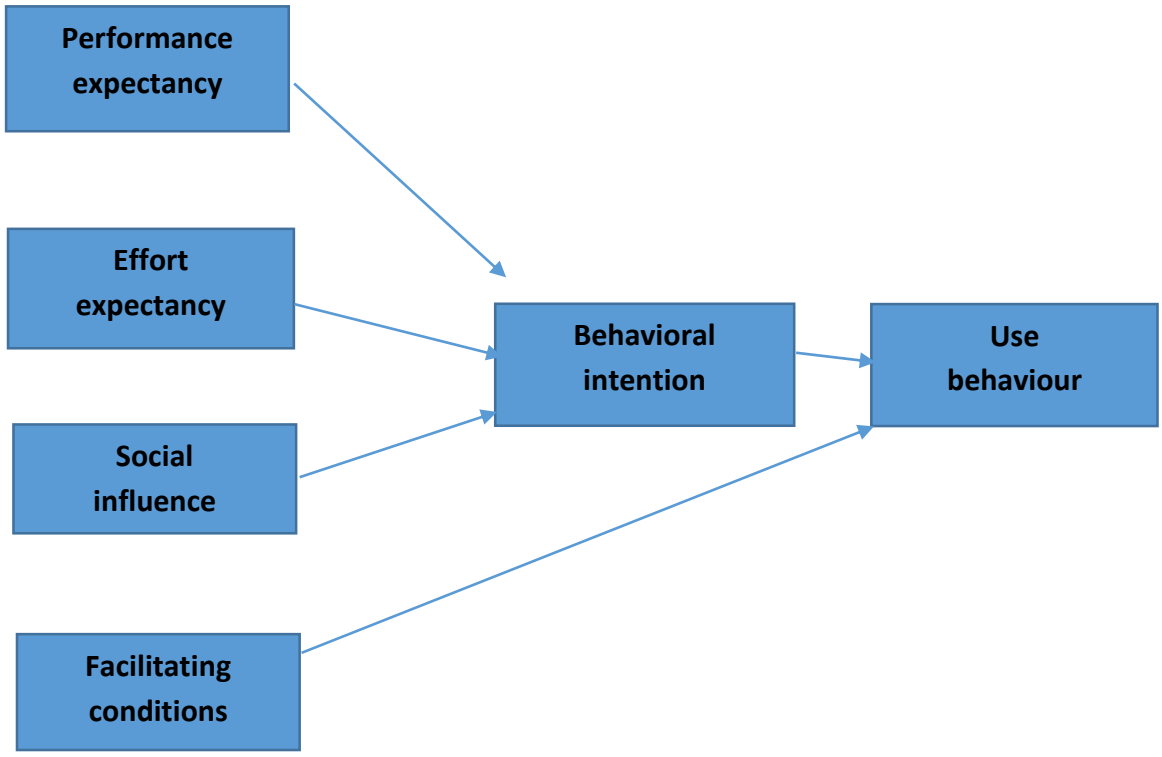
Abbad (2021) carried out research using a unified theory to understand the usage of the system of e-learning in developing countries. The main aim was to explore factors that impact the application of e-education in developing countries. The findings revealed that the student's acceptance of the usage of technology lies within their behavioural intention, which also relies on the performance and effort expectancy. Students who believe that the use of technology does not require effort, have high tendency to use digital tools. This exploration corresponds with the results obtained by Liebenberg et al. (2018). Based on the model's constructs, the study revealed that South Africa, and Africa as a whole experience infrastructural challenge, as it forms part of facilitating conditions (Venkatesh et al., 2003).

Abbad (2021) also indicated that facilitating conditions play a significant role in the adoption and use of e-learning platforms by students in higher education. According to this study, behavioral intention is not influenced by social influence, which implies that the actual use of technology does not require instructor or peer influence since these students are a digital nation (Abbad, 2021). In contrast to other studies, such as Haneefa (2023) on the evaluation of online flipped classrooms, revealed that all variables of the initial hypothesis proved to have a positive significance on intention of behaviour. According to Venkatesh et al. (2003), facilitating conditions did not indicate a positive impact towards behavioural intention.

Ab Jalil et al. (2021) carried out a study using UTAUT to explore teachers' behaviour on the application of technology in Malaysian primary schools, only social influence and facilitating condition variables had a direct significance on behaviour intention. Performance expectancy and effort expectancy had no impact on the behavioural intention to use technology in primary schools. The findings are in contrast with the initial hypothesis of the unified theory (Venkatesh et al., 2003).

2.3.5 The Reason for Choosing the UTAUT model

Venkatesh et al. (2003) managed to integrate multiple technology acceptance theories and models and came up with a unified theory called Unified Theory of Acceptance and Use of Technology (UTAUT). The aim of the UTAUT model was to avoid the confusion among the theories and models. The UTAUT model also integrated all key constructs of the other theories. The use of this theory was able to assist in developing an understanding of the teachers' perceptions on the use of ICT under the key tenets of the model, namely, performance expectancy, effort expectancy, social influences and facilitating conditions. To understand teachers' perceptions on ICT integration, UTAUT was used as basis for data analysis. The aim of the study excluded the moderators (age, gender, experience and voluntary to use ICT). Therefore, the UTAUT model was modified and the moderators were excluded, as indicated in Figure 2.6.



(Source: Author's own design)

Figure 2.6: Modified UTAUT model

2.4 CHAPTER SUMMARY

According to the review of literature, it is with no doubt that the integration of technology in the education sector plays an important role improving and advancing the education sector and overall, the economy of the country. In order to implement and adopt ICT successfully, a national ICT programme is very important. The government initiates strategies on how ICT is integrated in schools while ensuring its development and sustainability. The key to the development of any countries' economy is through ICT integration in education. To successfully implement a system, the country needs a national policy whereby they set out the goals to achieve through ICT. It is evident that the government for each and every country has taken the initiative on the provision of proper ICT facilities, but the main obstacle being the socio-economic factor of that country. The national ICT policy of any country depends on whether the country is developed or developing. Developed countries such as Singapore and Thailand seem to have set clear master plans and succeeded since it was revealed that their development of ICT in education is very progressive. However, not all countries with clear ICT master plans guarantee the success of ICT integration in schools. This is evident in countries like Indonesia. African countries, including South Africa use different strategies to adopt ICT in education. Research has indicated that the implementation of ICT can never be effective if teachers' perception on the acceptance of ICT is taken for granted and not addressed. Teachers are believed to be the driving force of the implementation of ICT in school, hence their professional development need to be prioritised.

There are contradictory opinions about how teachers perceive the integration of ICT in the classroom, some thoughts were positive while some were negative. Most teachers agree that the integration of technology in schools can enhance the process of teaching and learning; however, there are challenges that influence how they perceive ICT integration. Teachers believed that it is time consuming to prepare lessons, technical issues are a problem when conducting lessons that are based on technology devices, learners are not safe since they also use inappropriate sources. Teachers view technology devices as saving time; however, some teachers feel that technology tools like the calculator does not enhance learners' critical thinking.

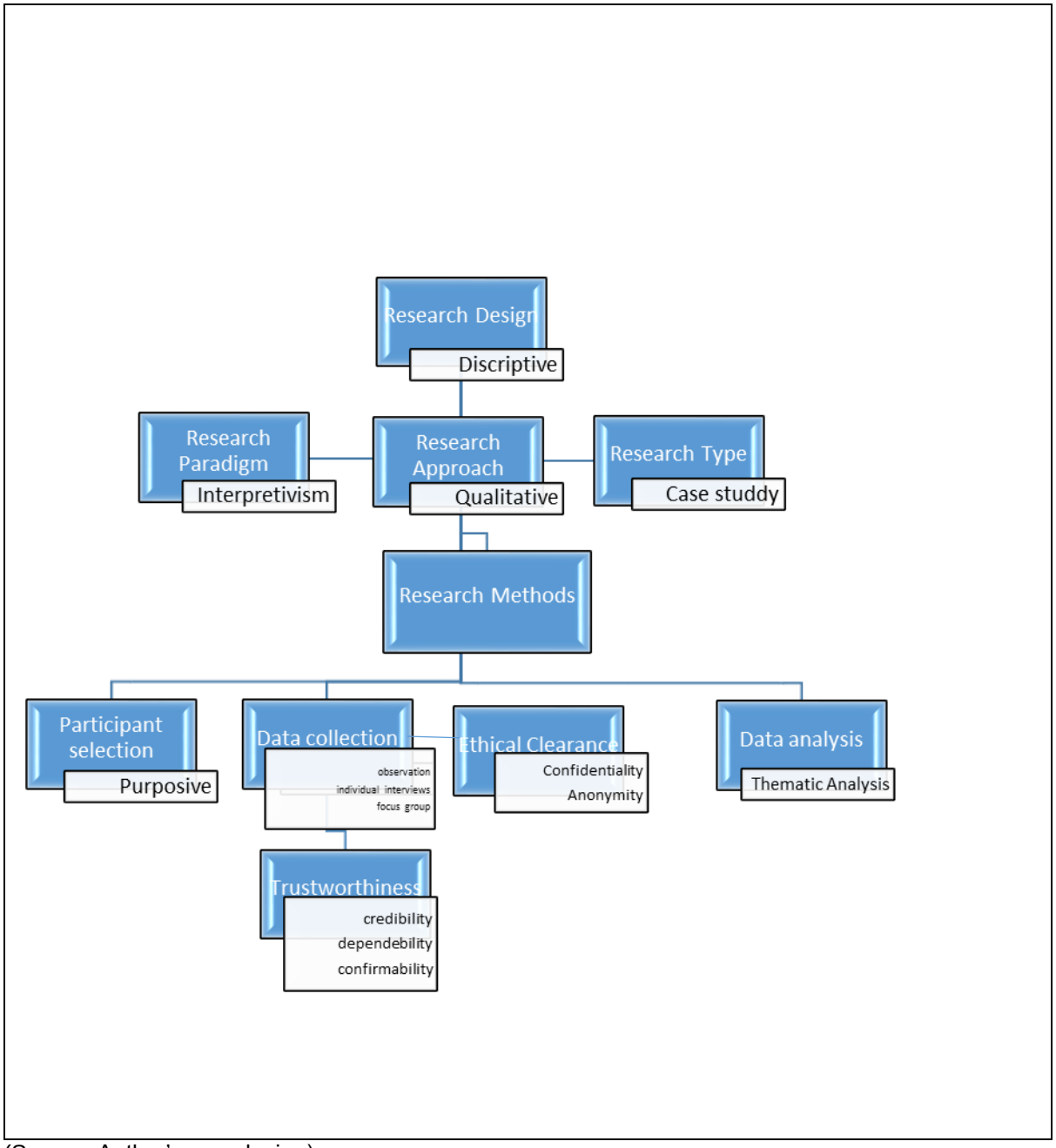
The inception and adoption of digital tools has proven to bring innovation and improvement in the education sector. This is supported by the benefits brought forward by the authors which include: raising curiosity among learners which results in outstanding engagement and participation. It saves time, promotes collaboration, it acts as an additional resource, it promotes content retention, learners easily understand the content. However, there are many challenges experienced by developing countries whether international or African countries like South Africa, Nepal, Nigeria and Rwanda. These challenges are due to external factors, such as power supply, insufficient funding, high cost, lack of infrastructure, lack of skills and ICT knowledge. There are also challenges that are internal, which includes teachers' hesitation on ICT integration during instruction due to the fact that they lack knowledge and they received insufficient or no training at all.

The last section of the chapter presented the theoretical model, the UTAUT model. The unified theory plays a vital role in shedding light on what education stakeholders can do to improve the incorporation of technology in pedagogy. Empirical evidence was collected on how this model has been applied by different authors in the education sector. Some authors applied the theory as it is, while some modified it by adding some of the constructs. Regarding various studies that were conducted, the key constructs from the hypothesis of the model (Venkatesh et al., 2023) have been in contradiction, while some have shown consistency. The application of this model by different authors revealed that the determinants of intention to use ICT vary according to different countries or contexts. This chapter presented detailed literature review and the theory that was employed in this study. The following chapter discusses the research design employed in this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The main objective of this research study was to explore the effects of ICT integration to teach Grade 7 mathematics in the Johannesburg East District. This was done through investigating the benefits, challenges, how ICT is being integrated and finally, teacher's perspectives on the utility of ICT based on the key tenets of the UTAUT model. To achieve these goals, it is necessary for the researcher to fully describe the research design of the study. This chapter explains in detail the paradigm employed in this study, which was chosen based on the ontological and epistemological assumptions of the study. The research paradigm plays a huge role on deciding on the elements of the research methodology, including research approach, research design, data analysis and measures of trustworthiness. The last section of this chapter explains the importance ethical considerations in research and how it was ensured in this study. The reason for doing this research has been prompted by the phenomenon of ICT integration into mathematics classroom since it has not been effectively employed in schools in the Johannesburg East District.



(Source: Author's own design)

Figure 3.1: Chapter overview

3.2 RESEARCH PARADIGM

Authors such as Maree (2016), Cohen et al. (2018), Creswell and Creswell (2018) and Mertens (2023) maintain that there is no single definition of the term paradigm. For example, Maree (2016) defines a paradigm as a set of presumptions of essential elements of reality that give rise to a specific perspective on the world view. Furthermore, Cohen et al. (2018) define a paradigm as the way in which we view the world, different assumptions on how we understand the world and ways in which we

pursue knowledge. Moreover, Creswell and Creswell (2018) denote a paradigm as a worldview, and define it as a fundamental set of ideas that directs action. Finally, Mertens (2023) defines a paradigm as ways in which we look at the world. Therefore, these assumptions are very useful in identifying which research approach, amongst qualitative, quantitative and mixed methods to utilise and explain why that research approach has been chosen (Creswell & Creswell, 2018). According to Cohen et al. (2018), there are various competing paradigms in educational context, including positivism, interpretivism and critical theory. This section broadly explains the types of educational paradigms with the aim of shedding light on why the chosen paradigm has been selected, based on its philosophical assumptions. Maree (2016) argued that these basic assumptions have their foundation in ontology, epistemology and methodology.

Ontology is defined by Maree (2016) as a collection of presumptions regarding reality. According to Cohen et al. (2018), ontology has its bases on truth or reality, existence and nature of being. It relies on theories and observations that are independent of people's perceptions, views and opinions (DeCarlo, 2018), and this is called realism (Maree, 2016). A good example of realism is given by DeCarlo (2018) which is the force of gravity, we know that it exists and it is real and independent of our opinions. Furthermore, from this discussion about ontology, one can conclude that this assumption is objective reality (DeCarlo, 2018). Moreover, there is also subjective truth which is dependent on people's (individual or groups) opinions and contexts (DeCarlo, 2018). Unlike objective reality, subjective truth has multiple realities since it depends on who is being observed and the context where they are observed (Cohen et al., 2018). Then the question would be, how do we know about these subjective and objective truths and realities, and this introduces us to the term epistemology.

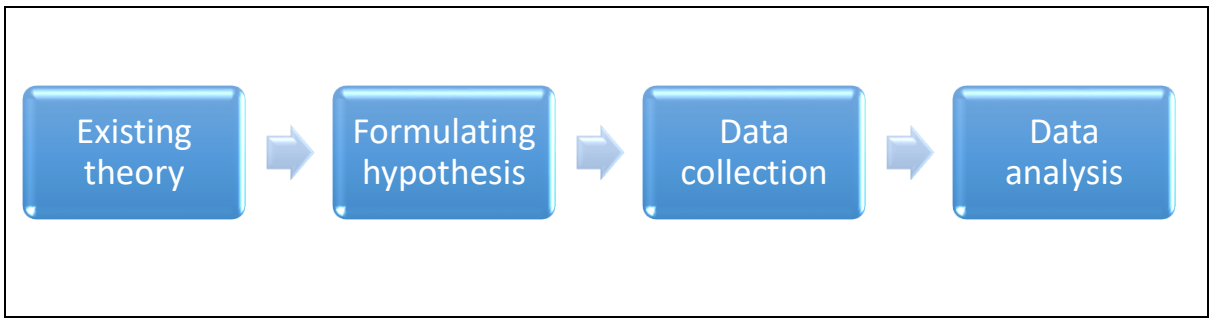
Epistemology is the nature of knowledge (Maree, 2016). It is concerned about how we know about something, the forms of knowledge, how knowledge is acquired and how we can convey it to other people (DeCarlo, 2018). In addition, it influences how we discover knowledge about the situations that are being investigated in different contexts (Creswell & Creswell, 2018). Moreover, DeCarlo (2018) believes that epistemology assists on deciding whether we have to collect data that is in the form of numbers (quantitative) or in the form of words (qualitative). The third assumption is methodology of the research. **Methodology** is concerned about the strategic

procedures that the researcher employs in terms of sampling, data collection methods, data analysis and issues of validity (Maree, 2016). The discussion of ontological, epistemological and methodology assumptions bring us to different types of educational research paradigms.

3.2.1 Positivism

The positivist paradigm holds the belief that the world is understood through the theories that already exist and require verification (Creswell & Creswell, 2018). Positivists assume that the existence of reality is not dependent on human understanding and beliefs and this is the ontological aspect of positivism termed realism (Maree, 2016). Furthermore, the epistemological aspect of positivism is subjectivism (Maree, 2016). Moreover, positivism is also known for its approach of deductive logic as a way of theory verification (Maree 2016). In addition, DeCarlo (2018) defines deductive logic as an approach in which research begins with a theory, and then formulates a hypothesis, data is then collected and analysed in order to test this hypothesis (illustrated in Figure 3.2).

Furthermore, Cohen et al. (2018) note that the positivist approach is the scientific method where experiments and observations are used to advance knowledge. According to Maree (2016), various methods like experiments, standardised tests, closed ended questionnaires, quasi-experiments, scales, standardised observation tools and structured interviews are utilised to generate data, resulting in numerical, quantitative data. In addition, the gathered quantitative data is analysed through inferential statistical analysis (DeCarlo, 2018). According to Guba and Lincoln (1994), positivists hold that the research is good if it has internal validity, external validity, reliability and objectivity.



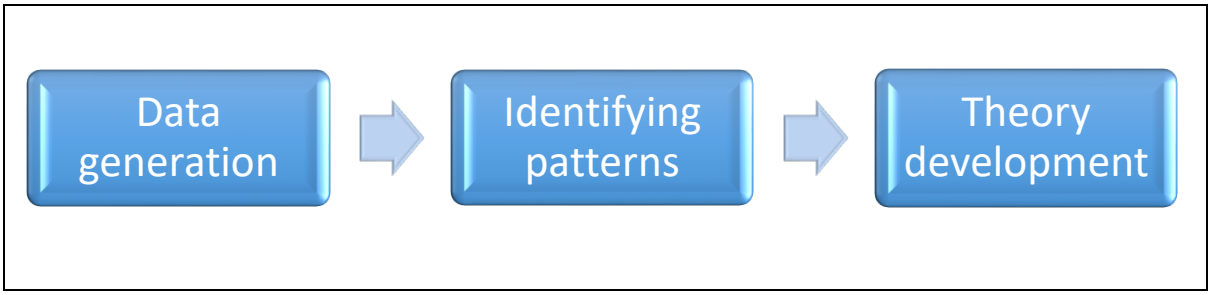
(Source: Adapted from Decarlo, 2018:155)

Figure 3.2: Deductive approach

3.2.2 Interpretivism

Interpretivism is the paradigm that is concerned about understanding and interpreting people's behaviour and interaction in the social context (Creswell & Creswell, 2018). This paradigm places its emphasis on the importance of the natural setting since there is more opportunity to understand the opinions individuals or groups have about their processes (Maree, 2016). Furthermore, Martens (2023) believes that interpretivists create meaning through interacting with participants in their setting, hence, knowledge is socially constructed. Additionally, because of its ability to construct knowledge, it is also called constructivism (Maree, 2016). Moreover, interpretivism is against the notion that single reality exists, independent of human senses (DeCarlo, 2018). In support of this notion, Cohen et al. (2018) believe that interpretivists hold that there are multiple realities, perspectives and interpretations in one phenomenon. Moreover, the reason behind multiple realities originates from the fact that data are collected from different participants who have different opinions about how they view the world (Maree, 2016). For instance, different teachers would not perceive the educational profession the same; one might perceive it as challenging while the other perceive it as fascinating, based on their experiences.

In contrast to positivism, reality and truth is generated not discovered (DeCarlo, 2018). The interpretivist epistemological assumption is subjectivism (DeCarlo, 2018) and in order to understand the world, the researcher depends on the views and experiences of the participants (Cohen et al., 2018). In contrast to positivists, interpretivists follow an inductive research approach (Maree, 2016) whereby they start by gathering data, they look for patterns so that they can interpret them and then they develop a theory (illustrated in Figure 3.3). In addition, according to Maree (2016), methods like observations, interviews, documents and physical artefacts are used to collect qualitative data. Moreover, according to Guba and Lincoln (1994), credibility, transferability, dependability and confirmability are used to measure trustworthiness of the research study.



(Source: Adapted from Decarlo, 2018:154)

Figure 3.3: Inductive reasoning

3.2.3 Critical Theory

This is the paradigm which emphasises bringing into light the social, cultural and political indifferences among people which is caused by power issues and inequality (Maree, 2016). In addition, according to Creswell and Creswell (2018), the people of interest in this paradigm are those who are marginalised. For instance, gender inequalities, whereby women are denied higher ranking positions in organisations, socio-economic status due to political reasons, unequal distribution of ICT resources in schools due to geographical location. Ontological assumption has its basis in historical realism. The assumption is that, there is reality that is shaped by cultural, political, gender and religious aspects (DeCarlo, 2018). Furthermore, epistemologically, critical theory is subjective, in that, it is assumed that no object can be researched without being affected by the researcher (DeCarlo, 2018). Researchers who employ critical theory are not only trying to understand the problem, but their goal is to change the situation in order to emancipate the society from social injustices and inequality (Maree, 2016). Hence, Creswell and Creswell (2018) alternatively call this paradigm a transformative paradigm. Furthermore, they also do research in order to investigate which beliefs limit the society in order to transform those issues (DeCarlo, 2018). Moreover, the methodology of critical theory is mixed methods, which is the combination of qualitative and quantitative study approach (Mertens, 2023). Furthermore, it depends on the researcher as some may prioritise qualitative approach, while some may prioritise quantitative approach (Mertens, 2023).

The following table (Table 3.1) summarises the epistemological and ontological assumptions of the above discussed educational research paradigms.

Table 3.1: Ontology and epistemology assumptions of paradigms

PARADIGM	ONTOLOGY	EPISTEMOLOGY
Positivism	Realism Objective truth Reality is single and universal. Reality is independent of human beings	Objectivism: it is possible to provide an objective account of reality Representationalist
Interpretivism	Subjective truth Reality is socially constructed. Multiple realities	Relativistic Pluralistic
Critical theory	Historical realism Reality is independent of the researcher, but it should be changed	Objective account of reality with historical/social change informed by critical theories

(Source: Author's own design)

3.2.4 Justification of the Chosen Paradigm

The phenomenon at hand was the investigation of the effects of integrating ICT to teach Grade 7 mathematics in the Johannesburg East District. The study aimed to explore the benefits, challenges, how ICT is integrated in mathematics teaching and learning, and teacher's perceptions on integrating ICT in mathematics. In order to achieve these objectives and answer the research questions, it was necessary for the researcher to be in the context with the participants so that she would be able to understand their experiences. This is in correspondence with the ontological assumption of interpretivism which states that reality is socially constructed by the researcher (Maree, 2016). In addition, interpretivists hold the belief that the researcher relies on the views of the participants (Cohen et al., 2018). The study was highly dependent on Grade 7 mathematics teachers' experiences and perceptions about ICT integration.

Data collection methods of the study included classroom observations and interviews, which would yield rich and qualitative data in the form of texts/words. Open-ended questions were used to allow participants the opportunity to express themselves. Unlike positivism, which holds that there is a single reality that needs to be verified, interpretivists assume that there are multiple realities. Moreover, the study has no basis on the historical realism, as assumed by the research that is located in critical theory. The assumptions of this study are embedded in interpretivism; hence the study was positioned in interpretive paradigm.

3.3 RESEARCH APPROACH

Creswell and Creswell (2018) define the research approach as the procedure which involves different steps on how the research is to be carried out, from philosophical assumptions to research methods. Furthermore, there are many decisions that need to be considered before one chooses a research approach, and these decisions need to make sense (Creswell & Creswell, 2018). Decision making is informed by the philosophical assumptions that align with the research study, research design and research methods (DeCarlo, 2018). This section discusses in detail the three research approaches (qualitative, quantitative and mixed methods) and outline which approach was used in this study.

3.3.1 Qualitative Research

This is an approach whereby the researcher explores, understand and interpret the meaning that the humans assign to social issues (Cresswell & Cresswell, 2018). Furthermore, Maree (2016) points out naturalistic as one of the characteristics of the qualitative research since it prioritises the natural environment where human interaction takes place. Moreover, researchers who conduct a qualitative study are more interested in how individuals position themselves in their environment and how they make sense of the world around them (Maree, 2016). As mentioned in interpretive paradigm that the deductive approach is applied, Rosenthal (2018) emphasises the importance of ignoring the hypothesis that might exist at the beginning of the research. In addition, Maree (2016) describe the research types that are employed in qualitative study as case studies, ethnography, grounded theory, narrative research and phenomenological. Furthermore, the sample size is small and is selected purposefully based on the characteristics that are suitable for the study (Maree, 2016).

The researcher who locates their study in qualitative approach aims for deeper understanding of the phenomena, hence, the generation of data that is in detail and rich in information is necessary. In order to obtain rich information, researchers would opt for data collection methods such as observations, interviews, focus group interviews, document analysis, role playing, open-ended questionnaires and visual data analysis (Cohen et al., 2018). Furthermore, during observations, the researcher can be a participant or non-participant while interviews can be semi-structured, unstructured or interactive (DeCarlo, 2018). Qualitative data collected is in the form of

text or words. In contrast to quantitative data analysis whereby inferential statistical analysis is used, content analysis is employed since the collected data is in texts or notes. Research is considered to have good quality if it has credibility, transferability, dependability and confirmability (Guba & Lincoln, 1994)

3.3.2 Quantitative Approach

This is an approach which entails testing theories by investigating the relationships among variables (Creswell & Creswell, 2018). It also describes the trends among variables (Maree, 2016). For instance, it can be used to compare matric results among males and females, in five consecutive years. According to the epistemological and ontological assumptions discussed under the topic of research paradigms, it is evident that a quantitative study is located in positivism. In quantitative research, random sampling is employed, a large sample size, representing a large population in order to allow generalisation of results (Maree, 2016). Furthermore, instruments like experiments, quasi-experimental designs, surveys and correlation research designs, questionnaires are used to collect data, yielding data that is in numerical form (Maree, 2016). In contrast to qualitative research, these instruments consist of closed questions which normally include multiple-choice questions or yes/no responses (DeCarlo, 2018). In addition, data collected through a quantitative approach is analysed through descriptive or inferential analysis in order to draw conclusions (Cohen et al., 2018).

3.3.3 Mixed Methods

Mixed methods incorporates both qualitative and quantitative methods of enquiry (Creswell & Creswell, 2018), with regard to philosophical assumptions, research methods and data analysis (Cohen et al., 2018). Furthermore, Creswell and Creswell (2018) posit that the combination of quantitative and qualitative methods yields additional insight, beyond what an individual approach might have produced. Moreover, in this type of research approach, the researcher gathers both numerical data and data that is in the form of texts (Maree, 2016). There are many assumptions concerning the foundation of mixed methods since qualitative research is located in interpretivist paradigm and quantitative approach is positioned in positivism (DeCarlo, 2018). In addition, the mixed methods approach brings together the ontological and epistemological assumptions of different paradigms (DeCarlo, 2018). Moreover,

Cohen et al. (2018) believes that mixed methods approach offers a deeper understanding of the phenomenon than the individual methods. As a result, it is suitable to solve more complex issues meaningfully (Cohen et al., 2018). Furthermore, this approach holds the power of eliminating bias and increased reliability through triangulation (Cohen et al., 2018).

The following table summarises the comparison between quantitative and qualitative research.

Table 3.2: Comparison between qualitative and quantitative approaches

	QUALITATIVE	QUANTITATIVE
Research type	Case studies Ethnography Grounded theory Narrative research Phenomenological research	Experiments Surveys Quasi-experimental research designs
Sampling method	Non-probability sampling (purposive sampling)	Probability sampling (random sampling)
Data collection methods	Observations Interviews Focus group interview Document analysis	Experiments Surveys Close ended questionnaires Structured observations
Data analysis	Content/ discourse analysis Thematic analysis	Statistical analysis
Measure of trustworthiness	Credibility Transferability, Dependability Confirmability	Internal validity External validity Reliability Objectivity.

(Source: Author's own design)

3.3.4 Justification of the Chosen Approach

Firstly, guided by the ontological and epistemological assumptions of the interpretivist paradigm, this study employed a qualitative approach. In contrast with objectivity of its quantitative counterpart, qualitative study is rather subjective, according to interpretivism. The researcher depends on human perceptions in order to understand the world. This is one of the reasons the qualitative study has been chosen. The study aimed to explore the effects of ICT integration in Grade 7 mathematics classroom, therefore, the researcher depends on mathematics teacher's perceptions and experiences in order to understand the effects of ICT incorporation in mathematics classroom. Because a range of mathematics teachers from different schools were

sampled as participants, multiple realities were expected, instead of a single reality. Multiple realities were created because teachers have different opinions about how they perceive integration of ICT in mathematics classroom, the benefits and challenges also differ depending on the contextual factors.

In qualitative research, data are generated through being in the field with participants, the emphasis being the significance of the natural setting. In order to understand the effects of ICT integration in mathematics classroom, knowledge is socially constructed through visiting selected schools and interacting with teachers and learners in the form of classroom observations and interviewing teachers. In this way, the researcher had the opportunity to understand how teachers integrate ICT in schools, how learners react when lessons are presented using ICT tools, and the benefits received and challenges that teachers encounter, and how they deal with these challenges.

Using a qualitative approach facilitated the understanding of how teachers perceive the integration of ICT in mathematics instruction, whether it enhances teaching and learning of mathematics and its effect on learner performance and achievement. Through these methods of data collection, the resulting data were rich and detailed, consequently resulting to a deeper understanding of the problem being investigated. The study followed an inductive approach, whereby data were collected, followed by analysing and interpreting data and finally generating theory based on the findings. In conclusion, a qualitative approach has been chosen based on its assumptions of subjectivity, multiple realities, the importance of human perceptions, the significance of the natural environment and the social construction of knowledge.

3.4 RESEARCH DESIGN

The following section discusses different research types that are used in qualitative study, with the goal of identifying the research type that is suitable for leading to the clear understanding of the teacher's experiences and perceptions about the integration of ICT in mathematics classroom. Maree (2016) identifies phenomenology, grounded theory, ethnography, narrative studies and case study, as research designs of a qualitative study. After the discussion of these research types, one was selected to guide this research study.

3.4.1 Phenomenology

Phenomenology is an approach which is based on the meaning that is attached to people's lived experiences (Sandi-Urena, 2018). In correspondence, Maree (2016) believes that it is based on what people experienced and how they experienced that situation. Maree (2016) gives the example of grief, whereby the researcher collects information from people who experienced grief, the main focus being the description of what the participants have in common as they experienced grief. Maree (2016) puts the emphasis on the researcher's avoidance of bias and prolonged interviews as a method of data collection.

3.4.2 Grounded Theory

In contrast with phenomenology, grounded theory does not only describe people's experiences, but the main goal is the development of the theory (Maree, 2016). The development of this theory is grounded in the information that has been collected from individuals who experienced the phenomenon (Cohen, Manion & Morison, 2018). Furthermore, grounded theory differs from other qualitative research types because it seeks to generate theory after the data collection process. Moreover, the grounded theory follows inductive rather than deductive reasoning and interviews are used for data collection (Maree, 2016).

3.4.3 Ethnography

Ethnography is the research type which focuses on interpreting the whole society's cultural norms, values, beliefs and behavioural patterns (Maree, 2016). For instance, the study based on the educators of the entire institution or the cultural practices pf the whole community. The researcher spends much time with participants in the field in order to observe the cultural systems of that particular community in their natural setting (Maree, 2016). Cohen et al. (2018) believe that ethnographic research goes beyond interpretation, but aims to understand the dynamics of the cultural society and describing what individuals can learn from the particular cultural practices.

3.4.4 Narrative Studies

Narrative studies is a research type whereby people tell stories of their lived experiences (Maree, 2016). Furthermore, Maree (2016) states that researchers who positions their study in narrative research, gather these stories, analyse and retell

them. Time, scene, plot and place are the core tenets in narrative research and vital in creating quality of the narrative (Maree, 2016). The scene tells us about the place where the story was created, while the time is the essential part of the plot, which tells us when did the story happen, in the past or presently. Furthermore, data collection methods include storytelling, journal records, interviews, written letters and autobiography (Maree, 2016).

3.4.5 Case Study Research Design

Case study research is a research design which entails studying the problem intensively in its natural environment, context or setting over a period of time (Yin, 2009). The case is defined by Maree (2016) as a bounded entity (social issue, an institution, an individual or behavioural condition) whereby the boundary between the conditions of the environment and the case is indistinct. Schoch (2020) indicated that this boundary is vital because it ensures that the researcher focuses their research without going too broad. Maree (2016) believes that the case can be bounded by time, space, activity and context. Yin (2009) suggests that the case study is preferable in investigating contemporary phenomena. Case studies can either be single or multiple designs. Various methods of data collection are utilised, including observations, interviews, focus group interviews and documents analysis (Maree, 2009), which is the unique strength of a case study among other research types (Yin, 2009). In addition, Schoch (2020) suggests a purposive sampling when one intends to do a multiple-case study.

The following table, Table 3.3, summarises the research types in a qualitative study as discussed above.

Table 3.3: Qualitative research designs

	PHENOMENOLOGY	GROUNDED THEORY	ETHNOGRAPHY	NARRATIVE STUDIES	CASE STUDY
Focus	Understanding the meaning attached to people's experiences about a phenomenon.	Theory development grounded from data collected	Interpretation of social or cultural group.	Exploration of an individual's life.	In-depth understanding of single or multiple cases.
Data Collection Methods	Prolonged interviews with maximum of 10 people.	Interviews with a large number of people (20-30 people)	Observation Interviews Artefacts	Documents and interviews	Observations Interviews Document analysis Physical artefacts
Data Analysis Technique	Statements Meaning themes Experience general description.	Open coding Axial coding Selective coding Conditional matrix	Discussion Analysis Interpretation	Historical content Stories	Description Themes
Reporting Form	Description of the core aspects of the experience.	Theory/theoretical model	Description of the living pattern of a cultural group.	Description of one's life/ a detailed picture.	In-depth description of cases or a single case.

(Source: Adapted from Maree, 2016:75)

3.4.6 Justification of the Chosen Research Type

These methods have many common aspects as they are from the umbrella of qualitative research, for instance, common data collection methods. Firstly, the choice of the research type depends heavily on the question of the research (Yin, 2009). Furthermore, in cases where the question requires an in-depth understanding of the social phenomenon, the case study is compatible (Yin, 2009). In contrast to other research types, the study had no intention of retelling someone's story as per the inquiry of the narrative study, or interpreting a social or cultural group, as per the ethnographic study's inquiry. The researcher used the case study to deeply understand the effects of ICT integration in Grade 7 mathematics classrooms, through teacher's experiences and perceptions. Furthermore, amongst other competing research types, the case study holds the power to allow the researcher to adjust questions during the data collection process if the originally prepared questions do not produce relevant data (DeCarlo, 2018). In this study, it offered the researcher a chance to use different methods of data collection, thus producing in-depth information (Schoch, 2020).

Secondly, according to Yin (2009), the choice of the case study also depends on contemporary events, as opposed to historical events. The integration of ICT in mathematics classroom is the current event, that is occurring in education sector, hence the case study was best suited for the study. Lastly, the choice of the case study is also characterised by the degree of control to which the researcher has on behavioural events (Yin, 2009). In this study, the researcher focused on how teachers administer their lessons while incorporating ICT tools, also focusing on how learners respond towards the lesson. The researcher never interfered during the lesson and did not manipulate the conditions of the lesson, but rather observed and recorded the observations.

When designing a case study, the primary distinction is between multiple and single case designs. A single case study can be chosen based on whether the case is unique or extreme, it is a revelatory case, a longitudinal case, typical or representative case or when testing a well formulated theory (Yin, 2009). Furthermore, multiple case studies are defined as a collection of individual studies undertaken to obtain more specific information (Cohen et al., 2018), in which replication is the rationale (Yin,

2009). In contrast to a single case study whereby just one school would be used as a case, this study employed a multiple-case study whereby four schools were selected as cases. A multiple case study has been selected due to its ability to offer deeper information, while expanding the understanding of the phenomenon being investigated. The use of multiple-case design in this study contributed to the credibility, reliability, transferability and applicability because more data to support evidence was collected, indicating that the findings could also be applicable to other findings.

3.5 RESEARCH METHODS

The paradigm and research approach have been discussed which gives guidance on which research methods were selected. Research design involves planning on sampling methods, data collection techniques, data analysis and lastly the issues of reliability and validity. This part of the study discusses and outlines the research methods that were employed in this study.

3.5.1 Sampling

Sampling is the process of identifying and selecting people or elements that were used to collect data (DeCarlo, 2018). Moreover, Cohen et al. (2018) attest that an appropriate sampling strategy plays a huge role in ensuring the quality of research. In addition, there are two major classes of sampling strategies, probability and non-probability sampling (Maree, 2016)., Qualitative researchers use non-probability sampling while quantitative researchers use probability sampling (Maree, 2016). Probability sampling is the sampling technique where the chances of an individual to be part of the study are known (Horne, 2018), and they are popular for random sampling (Maree, 2016). Furthermore, probability sampling is selected from a larger population group and it is suitable for generalising findings and it is one of the requirements of statistics and experiments (DeCarlo, 2018). Examples of probability sampling techniques, as outlined by Maree (2016) include simple random sampling, stratified sampling, systematic sampling, cluster sampling.

In contrast, non-probability sampling is defined as a sampling strategy whereby the chances of the participant being chosen to participate in the study are unknown (Cohen et al., 2018) and is applicable when the researcher has a target group for the study (DeCarlo, 2018). There are different types of non-probability sampling including

purposive sampling, quota sampling, snowball sampling and convenience sampling (Maree, 2016). DeCarlo (2018) suggests that researchers who locate their study in qualitative research must ensure that they select a sampling method that will allow them to obtain a deeper information and understanding of the situation being studied. The following discussion on sampling types will focus only on non-probability sampling as it is the strategy which benefits qualitative approach.

3.5.2 Types of Non-Probability Sampling

3.5.2.1 Purposive sampling

This is the type of sampling whereby the researcher selects participants based on the characteristics that aligns with the study (Maree, 2016). This implies that the researcher starts by identifying the desired characteristics and then conclude on the required participants (Cohen et al., 2018). For example, if the study is based on university institutions, lecturers and university students are likely to be participants. It should be taken into consideration that when using purposive sampling, one needs to choose a participant whom they know will be able to provide relevant information (DeCarlo, 2018). For instance, if the study is based on a mathematics teaching strategies, the researcher should not just choose any teacher, but it must be mathematics teachers with experience.

3.5.2.2 Quota sampling

This is the type of sampling which is conducted by forming categories, thereafter, subgroups are created according to these categories (Maree, 2016). Furthermore, it is the researcher's decision on how many subgroups should be created and the information is gathered from these subgroups (DeCarlo, 2018). For example, if the researcher aims to investigate the use of the physical library in the university, the researcher can group students according to their gender.

3.5.2.3 Snowball sampling

Snowball sampling is the non-probability sampling whereby the researcher initially relies on one or two selected participants (DeCarlo, 2018). This implies that the researcher chooses one or two participants, then those participants will assist in recruiting other participants (Cohen et al., 2018). Snowball sampling is referred to as chain-referral method and is useful especially when it is not easy to find desired

participants (Cohen et al., 2018). This type of sampling is often employed if the researcher's interest is in a co-ordinated group of individuals (Maree, 2016). Moreover, snowball sampling is also used in cases where the topic is sensitive, for instance, homeless people (Cohen et al., 2018).

3.5.2.4 Convenience sampling

Convenience sampling is the sampling technique whereby the researcher gathers information from anyone that is available or just because they have access to (Maree, 2016). Cohen et al. (2018) denotes it as accidental or opportunity sampling. Maree (2016) believes that it is mostly advantageous in exploratory research when the researcher's interest is to get an estimation of truth. For instance, learners who are being taught by the researcher can be selected through convenience sampling. Moreover, convenience sampling differs from other non-probability sampling types because it is also used in quantitative study (Maree, 2016).

3.5.2.5 Justification for purposive sampling

Purposive sampling was employed as the sampling strategy for this study. Firstly, this was a qualitative study, and purposive sampling is the non-probability sampling strategy used in a qualitative study. Secondly, amongst other non-probability sampling methods, purposive sampling was chosen because of its affordance to allow the researcher to choose participants that suit the desired characteristics of the research (Cohen et al., 2018). This implies that the researcher needs to be aware of the participants that could provide required information. The study was based on ICT integration in Grade 7 mathematics classrooms in Johannesburg East District and the context, schools and participants need to be selected with specific characteristics Table 3.4 below describes the characteristics that will be used to identify participants.

Table 3.4: Desired participant characteristics

DESIRED PARTICIPANT CHARACTERISTICS
1.Participants must be from schools that are located in Johannesburg East District.
2.They must be from schools that are equipped with ICT devices and tools.
3.They must be teaching mathematics in Grade 7.
4.They need to have knowledge of mathematics pedagogy.

5.They must possess knowledge of ICT integration in mathematics instruction.

(Source: Author's own design)

Maree (2016) suggests that in a qualitative study, the sample size is small and is selected purposefully based on the characteristics that are suitable for the study. In this study, four schools situated in Johannesburg East District were selected because they are equipped with ICT devices and tools. The proximity of the schools has been prioritised in consideration of the focus group interview. The researcher ensured that there is at least more than one grade 7 mathematics teacher per school. The criteria for selection of two teachers depended on mathematics teaching experience and ICT integration knowledge, in cases where there were more than three Grade 7 mathematics teachers per school. From each school, two Grade 7 mathematics teachers were selected to participate in the study, making a total of eight teachers. Due to certain reasons discussed as a limitation of the study, the number of participants resulted in seven mathematics teachers. Table 3.4 presents the participants and their relevant information.

Table 3.5: Participant information

PSEUDONYMS	DESIGNATION	QUALIFICATION	NUMBER OF YEARS OF EXPERIENCE
Teacher Andrew	HoD	BEd Degree	18
Teacher Victor	Educator	Honours in Education	6
Teacher Irene	Educator	BSc in chemical engineering	3
Teacher Mary	Educator	Phd in Mathematics	13
Teacher Solly	Educator	BEd Degree	7
Teacher Lucy	Educator	BEd Degree	18
Teacher Brian	Educator	PGCE	3

(Source: Author's own design)

3.5.3 Data Collection Methods

The study is located in interpretivist paradigm which holds the ontological belief that reality is constructed socially and there are multiple realities (Cohen et al., 2018). Furthermore, this paradigm also emphasises that reality is subjective. Unlike

quantitative research that is based on deductive logical aspect, qualitative approach starts by gathering data, identifying patterns and developing a theory (Maree, 2016). From these assumptions about the interpretivist paradigm and qualitative research, it can be deduced that the methods of data collection could include observations, interviews, document analysis and physical artefacts. In order to align with these perceptions, this study gathered data using observations, semi-structured interviews and focus group interviews, each of which are discussed below.

3.5.3.1 Observation

This is the method of data collection whereby the researcher interacts with the participants to understand and interpret the situation (DeCarlo, 2018). Furthermore, observations offer researchers the opportunity to directly share participant's experiences (Rosenthal, 2018), while also allowing the researchers to capture the moments as they happen (Cohen et al., 2018). In addition, observations hold the affordance of producing more authentic information (Cohen et al., 2018). Following is the discussion of different types of observations which are identified and explained by Maree (2016:91):

- **A complete observer**. The researcher simply observes without interfering in the process. It is least obstructive but holds the limitation of the researcher not understanding the situation being observed.
- **Observer as participant**. In this case, the researcher is involved in the situation but focuses on observing without influencing the dynamics of the environment.
- **Participant as observer**. The researcher becomes the participant and interferes in the dynamics of the phenomenon and also plays the role in altering it. The research works with the participants to come up with development strategies. This type of observation works better with action research.
- **Complete participant**. The researcher is a complete participant to such an extent that participants are not aware that they are being observed or they are not even aware that they are participants. This type of observation is rarely used since it is against the ethics of the research since the people being observed never grant permission.

In this study, the researcher visited four schools during mathematics period. Teachers were observed on how they present mathematics lessons while integrating ICT, the main focus being which ICT tools and devices were being used and how teachers used them. The main focus was on teachers, however, learner responses and reactions towards the lesson assisted in displaying the benefits and challenges that teachers encounter while using ICT tools. During observations, the researcher acted just as a complete observer without interfering with the teaching and learning process. The lessons were video recorded in order to ensure that no important information was left out. Observations were the first step in the process of data collection so that the researcher would able to question about what happened during observations, for clarity. Instead of eight lessons (due to the unavailability of one participant), seven lessons were observed. The duration of each lesson ranged between 45 and 60 minutes.

3.5.3.2 Interviews

This data collection method is in the form of a two-way conversation, wherein participants are asked questions by the researcher with the aim of understanding the phenomenon being studied (Maree, 2016). This is an instrument that is widely utilised in data collection (Cohen et al., 2018), allowing participants to communicate how they interact on a daily basis (Rosenthal, 2018). Qualitative interviews are very useful if they are used correctly, as they afford data generation that is detailed and rich. According to Maree (2016), there are different types of interviews, such as structured, semi-structured and unstructured interviews. Structured interviews entail questions prepared in advance and they are asked in a straightforward manner (Maree, 2016); however, structured interviews lack flexibility, also probing is inhibited. In contrast, unstructured interviews are done informally in the field (DeCarlo, 2018). Due to the limitations of structured and unstructured interviews, semi-structured interviews were utilised in this study as discussed in detail in the following section.

- **Semi-structured interviews**

Maree (2016) attest that semi-structured interviews are a method of data gathering which is commonly utilised for confirming and supporting data that has been collected

through other sources. The priority of this study was to gather data that is rich detailed and in-depth about the experiences of Grade 7 mathematics teachers in ICT integration. In order to attain this goal, open-ended questions which have been prepared in advance, accompanied by probing were the solution (see Appendix I). Semi-structured interviews allowed the researcher to probe (Maree, 2016), which DeCarlo (2018) defines as requesting more information from the participants. It is very important for the researcher to be attentive during the interview so that newly emerging information can be identified (Maree, 2016). Maree (2016) outlines various types of probing, such as the detail-oriented probe which answers 'what', 'where' and 'who' questions, the elaboration probe which is designed to request more about the response given, and lastly, the clarification probe which serves to confirm whether the response is understood.

Semi-structured interviews were the second step to the data collection process of this study. Semi-structured interviews were used to corroborate data collected during classroom observations. Semi-structured interviews were also used to gather data based on the investigation of benefits and challenges that hinder the process of integration of ICT in mathematics classroom. These individual interviews were conducted with seven Grade 7 mathematics teachers in schools and recorded. Semi-structured interviews were conducted in venues convenient for participants and not during teaching and learning time to avoid interrupting the lessons. Each interview took approximately 60 minutes. As soon as the interviews were concluded, they were listened to, in order to identify any gaps, which were addressed during the focus group interview. This is one of the reasons for conducting semi-structured interviews before the focus group interview.

- **Focus group interview**

Maree (2016) defines the focus group interview according to the assumption that it holds, which is the generation of a variety of responses and activation of left out details. During a focus group interview, the researcher facilitates the discussion to ensure that the participants are focused on the topic (Cohen et al., 2018). Due to the nature of this data collection method, it carries both strengths and weaknesses (Cohen et al., 2018). For example, focus groups are structured and even though they might occur in an unnatural setting, they produce more insight than in individual interviews and they

produce a large amount of data in a short period of time (Cohen et al.,2018). However, in focus groups, confidentiality is not guaranteed, and some individuals may not feel comfortable when engaged in group discussions (DeCarlo, 2018).

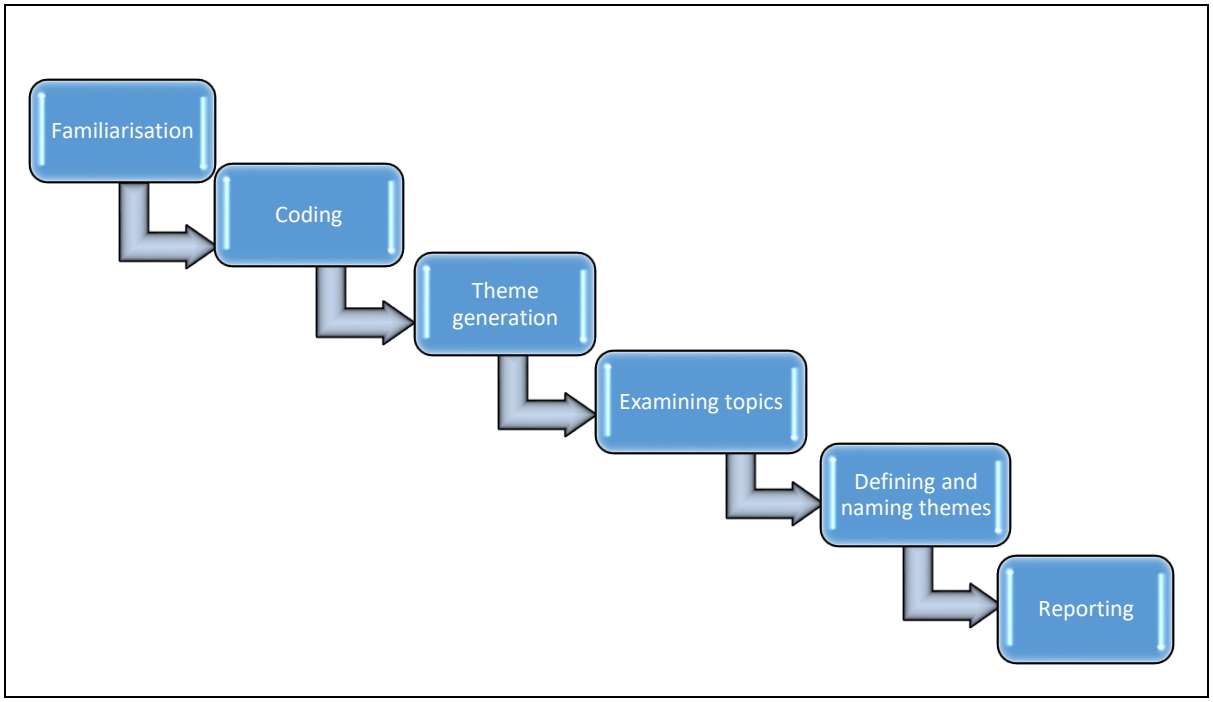
This is the third and last method of data collection that was employed. Seven mathematics teachers, who are participants were gathered in a common venue where they discussed the phenomena being investigated. The main focus of this group interview was to answer the last question of the research study which is based on the key tenets of the theory that guides this research. In contrast to individual semi-structured interviews, the focus group interview was able to reveal more information that might have been left out during interviews, participants were also able to build up on what the other participant said.

3.6 DATA ANALYSIS

As previously discussed, this study is positioned in the interpretivist paradigm and qualitative approach. To achieve the goal of obtaining rich data, observations, one-on-one interviews and focus group interview were conducted. In contrast with data collected under the study positioned in quantitative research, where descriptive and inferential statistics is utilised, qualitative data requires inductive analysis (DeCarlo, 2018). In this study, thematic analysis was employed to analyse data since it is in the form of notes.

3.6.1 Thematic Analysis

Thematic analysis is the technique of analysing qualitative data which entails reading through the notes, identify patterns and reporting interpreted data (Braun & Clarke, 2017). According to Terry et al. (2017) the process of thematic analysis is not strictly linear, because the researcher should go back and forth between these stages. Terry et al., (2017) describe thematic analysis phases as familiarising with data, generation of codes, generation of themes, reviewing potential themes, defining and naming themes and lastly, producing a report. Figure 4.4 outlines the steps that are involved in thematic analysis.



(Source: Student's own design)

Figure 3.4: Thematic analysis steps

Phase 1: Familiarising yourself with data

This is an entry point to qualitative data analysis, which entails the preparation of data collected, transcribing and getting to know it through reading (Terry et al., 2017). When transcribing, Maree (2016) advises on the importance of added elements in conversation such as gestures, laughter, reaction or expression when responding. At this stage, the researcher listened to the recorded tapes over and over again when transcribing, to ensure that none of the important information has been left out. The researcher read and re-read through the data set, not just mere reading, but with the aim of noticing patterns and asking questions about what is appearing in the data.

Phase 2: Coding

Maree (2016) defines coding as a process of carefully reading the notes and transcribed data and separating it into different meaningful segments called codes. These segments must have a meaning that is relevant to the research question/s (Maree, 2016), and the irrelevant data may not be coded (Terry et al., 2017). The researcher read all the data collected with an aim of grouping the data into codes. The codes were created taking into consideration the research questions. The large

amount of data was reduced into manageable proportions with identifying names. The irrelevant data has been filtered.

Phase 3: Theme generation

Theme generation involves examining codes, identifying similarities, patterns and relationships among the codes, then clustering them into huge meaningful patterns. (Terry et al., 2017). At this stage, the researcher identified the common central feature that underpins the theme. The researcher focused more on the subthemes that appeared, which were later categorised into main themes.

Phase 4: Reviewing themes

This is a vital stage of data analysis, whereby the researcher needs to review the themes, with the possibility of some themes being rejected (Terry et al., 2017). At this stage the researcher evaluated the subthemes, before drawing conclusions, to ensure that they align with the question of the study.

Phase 5: Defining and naming themes

At this stage, the researcher ensured that all the relevant data has been grouped into relevant themes. The following themes emerged: (1) the pedagogical benefits of integrating technology in grade 7 mathematics classrooms, (2) challenges in implementing technology in grade 7 mathematics classrooms, (3) ICT integration in the classroom and (4) teacher's perspectives on the integration of ICT in their teaching of mathematics.

Phase 6: Writing up

This is the final stage of thematic analysis, representing the bigger picture of the whole research (Terry et al., 2017). The researcher reported and interpreted the findings of the study. The researcher avoided repetitions and ensured that the report is not only about interpretation of collected data, but arguments based on the research question are also evident.

3.7 MEASURES OF TRUSTWORTHINESS

This section of the research fully explains techniques that were applied in this research to ensure quality. It is concerned about the meaning of quality in research, the

importance of quality and finally, the criteria that were employed to achieve the quality of qualitative research (Treharne & Riggs, 2015). Due to different epistemological and ontological assumptions, the quality of research in qualitative and quantitative study is ensured using different criteria. Research located in quantitative research is measured through internal validity, external validity, reliability and objectivity (DeCarlo, 2018). In contrast, trustworthiness in qualitative research is measured through credibility, transferability, dependability and confirmability (Treharne & Riggs, 2015).

3.7.1 Credibility

According to Lincoln and Guba (1985), credibility may be achieved by engaging with participants for the longest period of time for rich information and allowing participants to verify the material following data analysis. Credibility emphasises the importance of being confident in the outcomes delivered; they must be true.

Triangulation is established with the use of various and multiple data collection methods, sources and theories (Treharne & Riggs, 2015). Triangulation holds the power to reduce bias (Cohen et al., 2018). In this study, three methods were used for data collection; observations, semi-structured interviews and focus group interview, allowing for the exploration of ICT incorporation in mathematics classroom from various angles. Observations were done first, in order to be able to ask questions during semi-structured interviews about what had been observed in the classroom. The use of semi structured interviews also ensured that the information that the participants provided corresponded with what had been observed in the classroom. A focus group interview was conducted as a follow up process of the individual interviews. The use of these different methods of data collection in this study allowed for crosschecking of data, is authentic, it also allowed for examination of the integrity of the participants. In this way, bias was reduced, while increasing the credibility and the confirmability of the study.

Prolonged engagement meant spending time with the participants in the field leading to the collection of sufficient data (Cohen et al., 2018). In addition, Maree (2016) emphasised the importance of the context and social construction of knowledge in qualitative research, in order to understand the matter being investigated. The longer the researcher spends time in the field, the more the researcher gets to understand the core issue being investigated, and in addition, gains the trust of the participants

(Anney, 2014). In this way, participants might, overtime, reveal information that they might not have revealed initially (Anney, 2014).

To collect data that was credible, a longer period of time was spent with participants during the process of data collection. Firstly, the participants were visited in order to get to know them and explain the nature of the study and what is expected from them. Secondly, classroom observations were done on how ICT is integrated in mathematics classroom. Due to time allocation of mathematics, an hour was spent in each school for observations. Follow up conversations were conducted with participants telephonically to allow continuous contact within the field. Semi-structured interviews followed by focus group interview were then conducted. In this way, credibility of the study has been achieved.

3.7.2 Dependability

Dependability refers to the fact that if another researcher conducts the same research project, the outcomes must be the same. This can be accomplished by providing information on the path the research study travelled, which is referred to as an audit trail (Lincoln & Guba, 1985). An audit trail refers to the records and documentation of everything concerning the whole process of the research study (Cohen et al., 2018). These records include the data generation plan, raw data collected, how data was analysed and reporting of the findings.

In this study, to create an audit trail, a clear description of the steps that were taken to conduct the study has been documented. The field notes that were taken during classroom observations and transcribed data from interviews, which is regarded as a raw data, is available. To analyse qualitative data, coding is required, which eventually merges into themes. The process of how codes were created has been documented, together with the generation of the themes. Data interpretation and reporting is available.

3.7.3 Confirmability

If other researchers can corroborate the conclusions of the study, the study is valid (Lincoln & Guba, 1985). This criterion prevents researchers from being biased. The findings must not also reflect the researcher's interests, therefore leading questions are avoided. This means that the study's conclusions should be consistent with the

information provided by the participants. Confirmability is achieved through the provision of an audit trail.

Peer debriefing involves seeking guidance from professional peers (academic staff members or researcher's supervisor) who understand the process of research in detail in order to ensure the quality of their work (Cohen et al., 2018). Once the data had been collected and analysed, support and guidance was requested from the supervisor to comment and make any suggestions based on the analysis. My peer who is also doing master's qualification was also requested to peer debrief. This method also aided in ensuring credibility of the study.

Member checking is the process of sending back the data to the participants to ensure that their original information they provided has not been manipulated (Maree, 2016). This technique is very important because it eliminates bias (Maree, 2016). In this study, once data had been analysed, it was returned to participants to check and confirm if the analysis and interpretations authentically represent the original data. Participants confirmed the originality of the data collected from them. None of the participants had issues concerning the accuracy of data or any misinterpretations.

3.8 ETHICAL CONSIDERATIONS

There are numerous unique ethical considerations that comes with conducting a study involving humans (DeCarlo, 2018). Cohen et al. (2018) argue that ethics in research is concerned about what the researcher needs to consider in terms of what is good, wrong, right, bad, what should be done and what should not be done in the research study. Horne (2018) describes the importance of the Institutional Review Committee to verify that the researcher is aware and has been trained about the ethics of the study. It is important to give participants the relevant information so that they have a clear understanding of what is expected from them, the risks involved, the benefits, the purpose of the study and how it will be conducted (see Appendix D) (Cohen et al., 2018). In correspondence with this statement, Price, Jhangiani and Chiang (2015) outlines core principles of ethics, i.e. respecting people, concern for welfare and justice. Furthermore, respecting people means ensuring that consent is granted, concern for welfare means protecting participants against unnecessary harm,

ensuring confidentiality and privacy, lastly justice, which is concerned about vulnerability of participants (Price et al., 2015).

3.8.1 Informed Consent

Informed consent is defined as the participant's agreement to participate voluntarily in the study after being informed about the possible risks, benefits and the nature of the research (DeCarlo, 2018). Price et al., (2015) define informed consent as acquiring permission for participation, having informed the participants about everything that might affect their decision. The purpose of the informed consent is for the protection of the rights of participants, while also placing them at responsibility if anything goes wrong during the study (Cohen et al., 2018). Price et al. (2015) cautions about the importance of discussing and explaining what is in the consent form, not just expecting the participants to read the consent on their own (see Appendix E).

This study was conducted under the supervision of the University of South Africa; therefore, the first step was to obtain the ethical clearance from the Research Ethics Committee of the university (see Appendix A, Ref: 2024/03/13/57858357/06AM). As this study selected schools that fall under the Gauteng Department of Education (GDE) in the Johannesburg East District, it was necessary to request the permission to conduct the study in the selected schools (see Appendix B). The third step entailed sending a letter to the principals of the selected schools, requesting the permission to conduct the research at their school (see Appendix C). During this step, it is necessary to explain to the principals about all the important aspects of the research which include benefits of the study and the risks involved.

Teachers are core participants in the study; therefore, it was vital to request their consent to participate in the study. The letter of consent to the teachers was drafted and issued to them asking their consent to participate in the study, by being observed in the classroom, being interviewed and also participating in the focus group interview. All the components of the study were explained so that teachers were aware of what was expected from them. Classroom observations were part of the data collection methods; therefore, it was necessary to seek assent from learners (see Appendix G). As these learners were between ages twelve and thirteen, they are considered minors. Minors cannot give consent on their own, parents need to be involved. Parents of the learners involved were given a letter explaining everything pertaining the research,

asking them to allow their children to be part of observations in the study by signing an assent form.

3.8.2 Key Components of the Concerned Form

The following discussion gives clarity on the important aspects that should be included in the consent form. This section also explains how these aspects were applied in this study.

3.8.2.1 Nature of the study

From the definitions of the informed consent, Price et al. (2015) and DeCarlo (2018) posit that it is important to explain every detail of the study as that carries the decision towards granting permission of the study. In this study, the information about the nature of the study was presented and explained to the participants so that they were able to tell if there are any potential risks that would be involved. It also gave participants an idea of what to expect and what they would be asked to do. This study aimed to collect data through classroom observation, semi-structured interviews and a focus group interview. Giving this information to the participants gave them the opportunity to decide on their availability. The fact that the study also conducted a focus group interview, participants needed to be made aware of participation in a group with other members, whereby confidentiality could not be assured.

3.8.2.2 What is expected from the participants

Participants have the right to know about what is expected of them, before making conclusions about participating in the study (Cohen et al., 2018). For instance, in this study they are expected to teach a mathematics lesson in the classroom while integrating ICT tools. Participants are also expected to answer questions in one-on-one sessions and also in a group. Semi-structured interviews were employed which allowed the questions to be open-ended and also allowed for probing. All the participants were asked the same questions to ensure quality. There were no personal questions involved, only questions related to mathematics pedagogy and ICT integration during instruction were asked.

3.8.2.3 Perceived risks

It is unethical to hide information from the participants, it is called deception, participants must be aware of all the risks involved (Cohen et al., 2018). For instance,

this study carried no possible physical harm. The only observable risks might have been in using participant's time and inconveniencing them. Also due to the fact that a focus group interview was conducted, it was possible that confidentiality of the participants' responses might not be maintained by other focus group members. However, before the focus group interview began, the importance of confidentiality was communicated with all other members.

3.8.2.4 Benefits of the study

It is not always the case that the benefits of the study are directly to the participants and participants need to be aware of the benefits that accompany the study (DeCarlo, 2018). For example, there was no compensation for the study to be conducted; however, the findings add to the body of knowledge about the integration of ICT in mathematics classroom. Teachers will have an idea of the benefits, challenges of ICT integration in mathematics in Grade 7 classrooms. As challenges encountered were discussed, teachers will gain an insight on how they can overcome them.

3.8.2.5 Confidentiality and anonymity

Anonymity means participants' identities and privacy need to be prioritised by not revealing their names in any document (Cohen et al., 2018). In this study the identity of participants was protected through the usage of pseudonyms for identification. Confidentiality means keeping the participant's identity a secret, ensuring no one has access to that information (DeCarlo, 2018). The hard copy information has been locked in the cabinet and will be kept for five years, of which after it will be shredded. The information in electronic form such as transcripts, tape and video recordings will also be kept secure.

3.8.2.6 Voluntariness

It should be stated in the consent form that participation is voluntary and participants can withdraw at any stage of the process (DeCarlo, 2018). In this study, participants were made aware that they would be participating freely, hence there is no compensation for participating in the study. If the participant would want to withdraw from the study, they could do so even without having to give a reason.

3.8.2.7 Communication of the findings

Participants are obliged to know about the findings of the study and it is important to include how the findings would be communicated (DeCarlo, 2018). Contact details of the researcher were included in the consent form. For further questions about the research, contact details of the supervisor from the institution where the research is operating were also provided.

3.9 CHAPTER SUMMARY

This chapter explained in detail the strategic plan of conducting this study that aimed to explore teacher's experience when integrating ICT in the classroom. The components of the paradigm were discussed, which served as the starting point since it assists in shedding light on which research methods, research types, data analysis and trustworthiness measures to be used. Ontology, epistemology and methodology positioned this study in interpretivist paradigm. The assumptions of interpretivist paradigm located this study in qualitative research. Through qualitative research, the decision was made on the research type (case study), sampling method, data collection methods, data analysis and measures of trustworthiness. Finally, the importance of ethics of the research study was also discussed in detail and how it was applied in the study. The following stage of this research entailed data collection process through research methods discussed in this chapter, which will lead to the next chapter of this research study. The following chapter entails data presentation analysis and interpretation. The findings of the study are reviewed in depth and compared to other studies in literature. This is the most important stage since it addresses the study's question.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

The preceding chapter discussed the methods that were utilised to collect data in this study. Classroom observations, semi-structured interviews and focus group interview were carried out to collect data. The study focused on four ICT schools and eight Grade 7 mathematics teachers were sampled. The main aim of the research was to investigate the experiences of Grade 7 mathematics teachers in the Johannesburg East District in integrating ICT.

The research questions were:

1. What are the pedagogical benefits of using technology in Grade 7 mathematics classrooms?
2. What are the challenges in implementing technology in Grade 7 mathematics classrooms?
3. How is ICT integrated into Grade 7 mathematics classrooms in the Johannesburg East District?
4. What are Grade 7 teachers' perspectives on the use of ICT in the mathematics classroom?

The interpretivist paradigm and a qualitative approach were adopted which led to the choice of data collection methods. To answer the first and the second research questions, semi-structured interviews were conducted with seven teachers. To answer the third question, with an aim of understanding how teachers integrate ICT tools in mathematics, classroom observations were carried out. Lastly, a focus group interview was conducted to understand teacher's perspective on the use of ICT in mathematics teaching and learning. Data were then analysed using the thematic analysis (Braun & Clarke, 2006). Different themes were formulated and are presented in Table 4.1.

Table 4.1: Themes and sub-themes

	THEME	SUB-THEMES
1	Benefits of using technology in Grade 7 mathematics classrooms?	1.1 Enhancement of understanding of different mathematics content areas

		1.2 The impact of ICT on learners' concentration and academic improvement
2	Challenges in implementing technology in Grade 7 mathematics classrooms?	2.1 Lack of training on how to integrate ICT in mathematics 2.2 Technical challenges 2.3 Limited knowledge of mathematical software
3	ICT integration in Grade 7 mathematics classrooms	3.1 Teacher's ICT knowledge to integrate ICT in mathematics 3.2 The development of mathematical skills 3.3 Learners' reactions to the lessons
4	Grade 7 teachers' perspectives on the use of ICT in mathematics classroom	4.1 Performance expectance 4.2 Effort expectancy 4.3 Social influence 4.4 Facilitating conditions

4.2 THEME 1: BENEFITS OF USING TECHNOLOGY IN GRADE 7 MATHS CLASSROOMS

The study explored the benefits of integration ICT to teach mathematics in grade 7 and to achieve this, semi-structured interviews were conducted. Two sub-themes emerged: enhancement of understanding of different mathematics content areas and the impact of ICT on learners' concentration and academic improvement.

4.2.1 Sub-theme 1.1: Enhancement of understanding of different mathematics content areas

This sub-theme discusses the benefit of using technology such as virtual manipulatives in teaching and learning of mathematics. Virtual manipulatives hold the power to assist learners in understanding abstract concepts in mathematics. The content areas involved are transformation geometry and number patterns.

Teacher Andrew: "*In terms of transformation geometry, when you flip, they can see the flip actually happening using ICT. They can also see the translation like how, when*

you make things bigger and smaller, and stuff like that by adding, you know, two units to each side and so on. Even on reflection, it helps. So, I like to use a lot, especially with the geometry.".

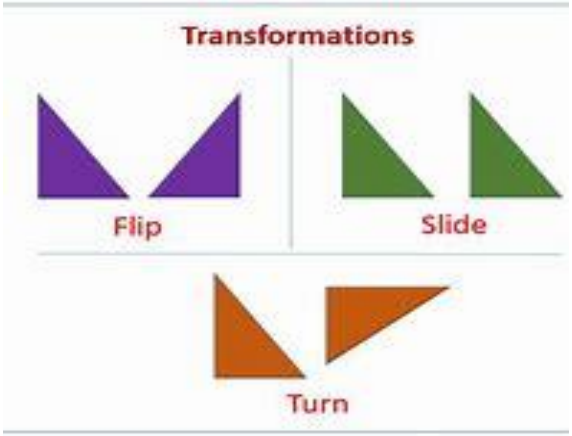


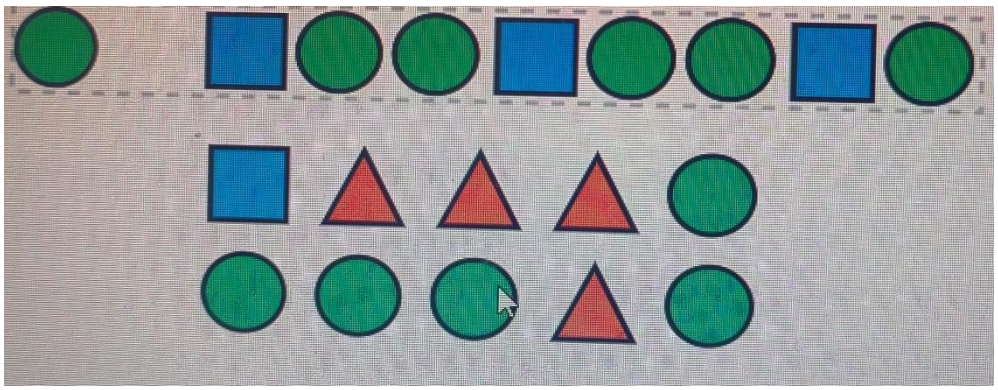
Figure 4.1: Transformation geometry

Teacher Andrew's statement indicates his knowledge of integrating ICT in transformation geometry. Transformation geometry involves translations, reflections and rotation. When explained through drawings as illustrated in Figure 4.1, only a few learners would understand this concept. He emphasises the importance of visualisation when teaching geometry. With ICT tools, learners are able to see how to transform an object. Learners can actually see how an object is rotated, reflected and translated.

Teacher Irene said: "*The number patterns, I think number patterns for me, because I'm actually starting, it's something that I'm working on now. I've seen where I introduced it with shapes. I said to them let's remind us our number patterns. And then I showed it to them in the form of shapes where I had a pattern that I had googled and I put on the board and they could see the colours changing and then they were able to go pick the shapes down at the bottom and then they just move them up to say okay, this is the pattern sequence so that's when it could drive into my lesson, Okay, a sequence is consecutive, you know, common difference or changes and stuff like that. So, in number patterns is also visual as well*."

Teacher Irene used virtual manipulatives to introduce the concept of numeric patterns. From what she stated, we can learn that she used a geometric pattern which is formed by different 2-D shapes, consisting of different colours. Learners are fully engaged as they are able to come to the board and form a pattern of shapes, as illustrated in Figure

4.2 below. From this, learners fully understand what a pattern is, and how it is formed. By the time the teacher introduces the concept of numeric patterns, learners would have acquired the knowledge of what a sequence is through the help of virtual manipulatives.



(Source: Adapted from: Toy theater online)

Figure 4.2: An activity based on geometric pattern

The findings of this study suggest that the use of manipulatives play a major role in mathematics classroom. It promotes learner-centred approach while facilitating the understanding of mathematical concepts. Authors such as Abdullahi and Sejaro (2022) also advocate for such as they posit that a learner-centred approach can be achieved through the use of ICT integration to teach mathematics. Similarly, Henderson (2020) attests that technology provides more opportunities to those learners who struggle to understand.

4.2.2 Sub-theme 1.2: The impact of ICT on learners

This sub-theme, which incorporates increased concentration and interest, understanding of the concepts and academic improvement and achievement. gives an insight into how learners benefit when ICT-based lessons are implemented, in terms of concentration, level of interest and improvement in learners' academic results.

Increased concentration and interest

Participants of this study believe that ICT integration is believed to create a conducive environment for teaching and learning in this era. It is also believed that technology promotes lessons that are fascinating. This theme discusses the impact of technology in the classroom regarding concentration and interest in mathematics lessons.

Teachers Lucy, Andrew and Mary had the same opinion about the concentration and the level of attention that learners display when they are taught using ICT tools in the classroom, as indicated in their statements below:

Teacher Lucy stated: *“And you know what I've noticed, these learners they concentrate more when you are using ICT when you just talking to them, they don't, they lose concentration. So, I think this ICT thing is a good thing”.*

Teacher Andrew stated: *“Yes, because at least there is more focus.”*

Teacher Mary said; *“They pay attention and listen attentively.”*

Teachers Lucy, Andrew and Mary shed light on increased concentration and the level of interest that learners show when they are being taught using ICT tools. From their statements, we can see that ICT integration in mathematics is able to grab learners’ attention, as they listen attentively and concentrate. Learners concentrate because it is not only about the teacher imparting knowledge to the learners, but the lesson becomes learner-centred and they are fully engaged in the lessons through hands-on activities.

Teacher Irene shared: *“I've seen some improvements where there are some kids that they're coming along. It's not just me. They're watching videos, I have kids in my class and says Ma'am, I went and looked at the maths long division video. And today, I'm doing much better”.*

Teacher Mary also confirmed that learners are becoming more independent with driving their own learning. Leaners can access videos on the internet, watch them at home and reinforce what they did in class to develop further understanding. The interest in mathematics also extends the teaching and learning process, from the classroom to home where learners can learn in their own time. If learners do not understand certain concepts in the classroom, through watching the videos at home, they enhance their understanding.

Participants of this study praised the level of interest in mathematics that is brought by ICT tools. Authors such as Henderson (2020) also advocate for this as they posit that technology is capable of bringing fun and enjoyment in the classroom through the use of games and other online teaching and learning resources. Similarly, Abdullahi and Sejaro (2022) said, mathematics lessons where ICT tools are integrated, learners’

interest increases and their attitude changes towards mathematics. A study conducted by Appavoo (2021) also revealed that during mathematics instruction, learners show great interest and motivation. The participants of this study also revealed that learners are able to watch videos related to the topic of the day, and in this way, they extend better opportunities for quicker and better understanding instead of waiting for the teacher. Authors like Das (2019a) attest to this as they maintain that the use of ICT extends the teaching and learning environment to outside the classroom. Similarly, Engelbrecht et al. (2020) said videos provide teaching and learning opportunities outside the classroom as learners are also able to watch videos at home. While the findings suggest that technology provides sense of dependency, Dhakal (2019) argues that the dependency of the learners on technology as a motivation to learn must be discouraged as learners might end up finding normal lessons boring.

Understanding of the concepts

Understanding of concepts relates to the level and the rate at which learners understand what is being taught in the classroom. The level of understanding is seen through the activities that are done in the classroom when learners are fully engaged in the lesson. The understanding depends on how the lesson is presented to the learners.

Teacher Brian explained*: "Well, I think maybe getting through concepts quicker than we would have done before. Like, if you introduce a topic, you can finish that topic in three days, rather than before, where you could take a whole week or two weeks to three weeks for learners to understand a certain concept if you introduce it, but with ICT it is much quicker. Learners actually grasp the content quicker with ICT.*"

Teacher Brian notes the effect the ICT has in terms of learners grasping and understanding the concepts. Learners are able to grasp mathematical concepts faster compared to when traditional methods are used. Teacher Andrew also notes that the time spent on teaching and learning of a particular topic is reduced when ICT is involved.

Teachers Andrew and Victor had similar opinions about the effect of ICT in learners' understanding of the content.

Teacher Andrew claimed: "*Content comes across to learners quicker using the ICT tools"*
Teacher Victor stated: "*I think for them also, as it becomes easier for them to understand the topics that we teach*".

Teachers Andrew and Victor are in agreement with Teacher Brian, that using ICT in the classroom develops the understanding of the concepts far quicker.

Teacher Brian also said*: "So, you find that you explain the concept maybe 50% of the learners understand. But if you introduce videos or pictures, then you get maybe the other 30% is now 70%. Then the other 10% If you add more, more material as well, you get 90% or if you're lucky 100%*

Teacher Brian explains how with the use of ICT in teaching mathematical concepts, a greater percentage of learners have understanding. This implies that the integration of ICT in the teaching and learning process assists in increasing the number of learners who understand the topic in the classroom. Teacher Brian's statement stresses the importance of integrating ICT since it increases the level of understanding among learners.
Technology has a major influence on learners' understanding of the content. Participants of this study reported that learners grasp the content much quicker if the lessons are presented using ICT tools. Mathematics consists of abstract ideas that are easily understood when they are brought into real life situations through the use of ICT tools. Authors like Das (2019a) also advocates for such as they posit that technology promotes the understanding of different mathematical content. Similarly, Appavoo (2021) attests that the use of ICT tools in the classroom has a vital role in promoting understanding of concepts in mathematics.

Academic improvement and achievement

It is surmised that the integration of ICT in the teaching and learning process will result in an improvement in learners' academic performance.

Teacher Andrew said: "*The achievement, it's not where we want to be, but we are getting there with the grade sevens*".

Teacher Andrew's statement indicates that although there is improvement in learners' achievement, it is not at the level expected. However, Teacher Andrew is positive that ICT tools have the possibility of enhancing learners' mathematics achievement, although this could take time.

Teacher Irene is in agreement: *"Performance slowly, but surely I'm seeing some improvement."*

Teachers Solly and Mary indicated that at the moment they are uncertain about the academic results but they are positive. Teacher Solly said: *"I think it's going to improve a lot"*

Teacher Lucy had a different opinion: *"The marks, there is no improvement, still the same, like we were using the old methods."* Teacher Lucy's statement indicates that whether ICT is integrated or not in mathematics lessons it has little or no impact on learners' academic improvement or achievement.

The use of the system can be accepted if it produces the desired results, in this case, academic improvement. In this study, teachers are not certain about whether ICT integration in mathematics has a guaranteed positive impact on learners' achievement. However, there is a slight improvement and they have hope that in future the outcome is improved performance. One participant argued that ICT has no improvement in learner's results. In agreement, Fernández-Gutiérrez, Gimenez and Calero (2020) indicated that there is no significant impact on learner outcome in mathematics through ICT integration. In contrast, Das (2019a) maintained that, through ICT integration, learners are able to demonstrate achievement which might not be achieved through outdated talk-and-chalk methods. Abdullahi and Sejaro (2022) argued that there is proof of positive impact on learners' performance if teachers have sound knowledge of the subject content and learners' understand the content if ICT is integrated. In line with previous studies, participants of this study could not confirm if ICT has had a positive impact on learners' achievement. To attest to this, Meladi and Awolusi (2019) indicated that there is no proof on how incorporation of ICT improves learner's performance with the shift to different technology platforms that are integrated in the teaching and learning process.

4.3 THEME 2: CHALLENGES IN IMPLEMENTING TECHNOLOGY IN GRADE 7 MATHEMATICS CLASSROOMS

The benefits that come with technology in education can never be over-emphasised as technology also comes with many challenges that teachers encounter. Semi-structured interviews were conducted to explore the challenges encountered by teachers. Three sub-themes emerged in this theme: lack of training on how to integrate ICT in mathematics, technical challenges and limited knowledge of mathematical software such as Geogebra.

4.3.1 Sub-theme 2.1: Lack of training on how to integrate ICT in mathematics

To effectively integrate ICT in mathematics, teachers need specific training. Mathematics is a unique subject that could be enhanced with the use of special mathematical software to achieve the expected outcomes. Without appropriate and adequate training, the integration of ICT may not be successful.

Teacher Victor explained: *"I received training of how to use ICT, more especially how to use smartboard. And also, we do have, uhm… I forgot the name of this programme where there's this lady who comes after school and then they teach us how to use word, PowerPoint, such things".* Similarly, Teacher Brian stated: *"Yes, yes, every Thursday there is training for ICT, there is someone who comes to school and teaches us how to use mainly PowerPoint or how to use the ICT gadgets in classes".*

It is evident that these teachers only received training on the use of ICT applications such as PowerPoint and MS Word. This information indicates that this type of training only relates to creating word documents which aid in preparing lesson plans, creating activity worksheets and any other administration purposes. Training on the use of PowerPoint assist teachers to preparing lessons to be delivered through the slides.

Teacher Mary said: *"The training, which we receive is just for ICT, how to use the ICT tools implemented in our school, the smartboard, the tablet, it was not specifically for mathematics."* Similarly, Teacher Brian stated: *"Not specifically in mathematics, just targets for the whole subjects that we're actually teaching. There's nothing that say that specifically is targeted for maths".*

It is noticed that the training that teachers receive is not specifically focused on mathematics. The concern is if this training is adequate for successful integration of

ICT in mathematics instruction and whether teachers are able to use ICT to enhance teaching and learning of mathematics.

Teacher Mary shared: "*For mathematics, I'm just using my own knowledge, how can I integrate it in my classroom*". Teacher Solly said: "We receive training, in ICT only, not how to integrate, but the training leads us to integrate with the lesson". Teacher Irene explained: *"I go home and say oh, okay, I can use PowerPoint for this. They tell us okay … how to use a Google form. A google form I can use it for invitation. You can use it for anything. So, then I'm like, Okay … I'm going to create a quiz for my kids of maths questions. It's how I integrate ICT into maths*."

The kind of training that teachers receive prompts their creative thinking of how they can integrate that knowledge to enhance mathematics teaching and learning. ICT integration in mathematics teaching and learning depends on teacher's creativity particularly if teachers believe that the training they receive could have an impact on learner performance.

The above findings revealed that participants only receive training based on operation of the ICT gadgets without any specific training on the integration of ICT in teaching and learning of mathematics. This finding is advocated by Ardiç (2021) who also revealed that a majority of teachers receive training on technical features of the gadgets not on how to integrate it in mathematics. Similarly, authors such as Barakabitze et al. (2019); Das (2019a); Henderson (2020); Al-Mamary (2020); Ardiç (2021) attest that there are insufficient opportunities for ICT training as it should be based on the curriculum so that teachers can be trained according to how they apply those skills to the teaching of specific subjects.

4.3.2 Sub-theme 2.2: Technical challenges

The challenges that hinder ICT integration in mathematics delivery are often in relation to technical issues. These challenges include poor network, load shedding, distribution of laptops, insufficient charging points and malfunctioning of ICT gadgets.

Teacher Mary stated: *"So first of all, the challenges we are experiencing is the network, we don't have a network. Yes, if you want to integrate, like the kahoot, we need the network. The Wi-Fi currently we don't have."*

Teacher Lucy raised the same concern: "*Another thing is Wi-Fi is not working we cannot go to Internet. We depend on the videos which are installed here only. We cannot explore, only those which are inside the smartboard to depend on them*".

Connectivity is the major constraint as teachers struggle to access online material to teach mathematics. This is corroborated by data gathered through classroom observations as Teacher Mary resorted to her own personal internet connectivity due to the unavailability of the Wi-Fi in the school. This causes a limitation because teachers cannot integrate technology to their full capacity.

Teacher Victor stated: "*Challenges will be, it's one load shedding. Sometimes you already prepared and then boom, load shedding, then it means that the lesson has to stop. The issue of internet … sometimes it's very slow. If you want to teach, then you find that, it's very, very slow and it takes up your time. Yeah, I'd say it's load shedding and the issue of the internet*".

Teachers raised the concern of load shedding, slow internet connectivity and no internet at all. Faced with these challenges, they are unable to access videos or to use visual manipulatives. As a result, they depend on the digital content that has been installed by the GDE on smartboards. The second challenge is the issue of distribution, charging and malfunctioning of learner's laptops, and this is what teachers had to say.

Teacher Lucy indicated: "*Every morning, we issue them out. Afternoon we take them, I retrieve and tick and tick, each and every learner have each one of them. They've got a laptop, if they are not using it, it means it is not charged*".

Teacher Andrew said: "*Okay, yeah. And then also the laptops, the learners have laptops, but to carry the laptops up and down every day. It's totally heavy. Also, sometimes it's damaged. Because one class will take 60 laptops and to go 60 laptops with four flights of steps gets damaged something"*

Teacher Irene indicated: *"What we're noticing now with new boards, eish, malfunction. Malfunctions, gadgets not working."*

Teachers distribute laptops to the learners in the morning and retrieve them in the afternoon. This is time consuming as they need to ensure that each and every learner gets their laptop and also that all laptops are returned in a good condition. However, when laptops are distributed, teachers often find that some are not working and some

are not charged, which causes a chaos due to the shortage of charging points in the classroom.

Participants of this study revealed that technical issues relate to the distribution of laptops and the issue that many laptops are not working properly, as well as the malfunctioning of smartboards and poor connectivity. Teachers had no issues regarding the delivery of mathematics content, but the challenges are based on technical issues. In line with this study, Das (2019a) indicated that these challenges include equipment that are not working and internet connection failure. Similarly, Dihtal (2018) pointed out that the insufficient physical infrastructure is a major constraint in ICT implementation. Authors such as Das (2019a), also advocate for this as they indicated that teachers avoid using ICT tools because of technical challenges that they face.

4.3.3 Sub-theme 2.3: Limited knowledge of mathematical software

Unlike other subjects, the effective use of ICT tools in mathematics Is through the use of software specially created for mathematics. These applications are able to enhance visualisation and manipulation of mathematical objects. This theme presents the findings on teachers' knowledge and their perspectives of mathematical software.

Teacher Andrew said: "*We use, okay, we used to use Geogebra but that time we had the licence, so now there's no licence for it anymore".* Geogebra is a freely available software that can be downloaded anywhere, on any device, so Teacher Andrew's notion of an expired licence reveals that he has limited knowledge of the software and its availability.

Teacher Mary said: "*Yeah, there is Geogebra but that one it's mainly for, if you want to do the angles. And yeah, for primary schools, not much, but you can use Geogebra for the angles when you want to calculate a total number of angles in a triangle, so that the learners can visualise what you mean*".

Teacher Mary has limited knowledge of mathematical software. She does know that Geogebra is used for visualisation purpose but feels that it is not that appropriate for use in primary schools.

Teacher Andrew said*: "And then Geogebra, I don't use it that much, with Grade 7. It's not that. How can I say? You can just touch on it, but you can't actually use like how you would use it in Grades 10, 11, 12"*.

Teachers Andrew and Mary also have a similar opinion that Geogebra is not suitable for primary school learners, specifically Grade7.

Teacher Victor said: "*First time I heard of Geogebra, from my colleagues, which is my HoD*". When asked if he received training on it, he answered: "*No, it was just explained. I wouldn't say it's a training it was just explained, to say this is how it works. And then I run there and checked and watch videos. And then I taught myself*".

Although Teacher Victor was introduced to Geogebra he has not undergone training on this application, and would still need professional development on its use.

Some teachers however, had no knowledge of mathematical software: Teacher Irene said: *"I'm not aware of apps per se, where maybe kids can play around and do the calculations"*.

Teachers Andrew and Mary are aware of the Geogebra software but feel that it is suitable for secondary school rather than for primary school learners. However, in contrast to the findings, Dahal et al. (2020) argue that learners need to be encouraged to use Geogebra to study mathematics at any level of mathematical knowledge. Similarly, Zilinskiene and Demirbilek (2015) noted that in primary school, geogebra plays a vital role in the development of geometric concepts. This finding shows that participants have limited knowledge of mathematical software use in primary school level.

4.4 THEME 3: ICT INTEGRATION IN GRADE 7 MATHEMATICS CLASSROOMS

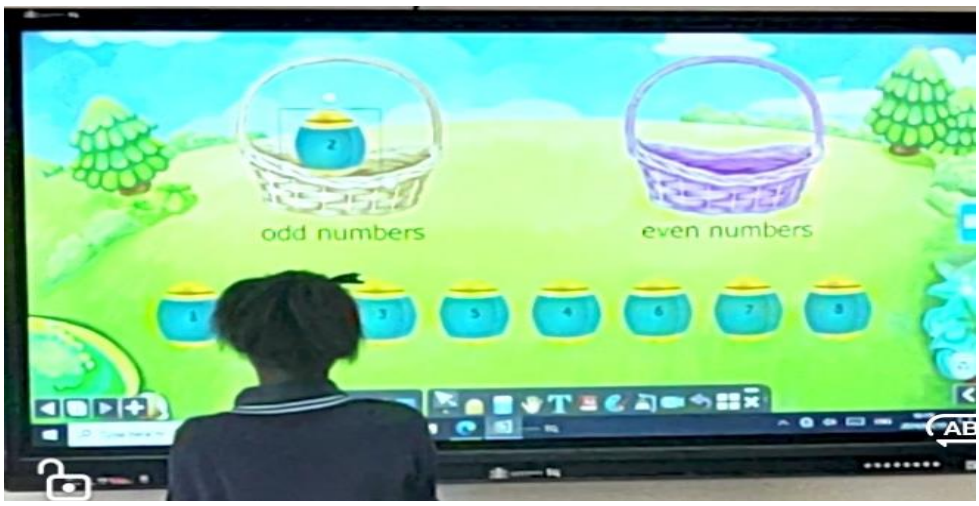
Classroom observations were conducted in four different ICT schools. The aim of the observations was to explore how Grade 7 teachers integrate ICT tools to teach mathematics. Three sub-themes emerged: teacher's ICT knowledge to integrate ICT in mathematics, the development of mathematical skills and learners' reaction towards the lesson.

4.4.1 Sub-theme 3.1: Teacher's ICT knowledge in integrating ICT in the mathematics lessons

Most teachers have demonstrated knowledge of operating ICT tools, but gaps were identified since this is mathematics-related research. The data collected during observations, regarding ICT skills, corroborates the data collected during interviews as teachers mentioned that they did not receive training specifically for a particular subject.

Teachers were able to operate the smartboard with ease. Teacher Mary successfully prepared a mathematics lesson on comparing numbers using PowerPoint. Teachers Lucy, Andrew, Irene, Brian and Victor used videos to facilitate teaching and learning. These videos were sources from YouTube or from my Supplementary Digital Learning Resources (mySDLR) app.

Teacher Solly conducted a lesson using the game-based learning platform Kahoot to do mental maths. He opened the app and learners had to do the activity. Firstly, the teacher used numbers that are far below the level of the learners. Learners were sorting even and odd numbers, and the numbers were one-digit numbers. Instead of using numbers such as 345 675, 234 897, 765 840 the teacher used single digit numbers such as 1, 2, 3, 4, 5, 6, 7, 8, 9. From this scenario, we can see that if ICT tools are not integrated properly, they can lead to teaching and learning that is not meaningful and beneficial to the learners.



(Source: My own design)

Figure 4.3: Activity on sorting even and odd numbers

Teacher Solly said: "*Ok, there are the numbers, then we going to put them according to their places. So, anyone who can come and do it for me?*".

Learners raised their hands and Teacher Solly invited one learner to come to the smartboard and sort the numbers. While the learner was sorting out the numbers, 2 perfectly fitted in the odd numbers and 7 perfectly fitted in the basket of even numbers. When the learner was done, learners applauded.

Teachers Solly: "*Ok let us move to the next activity".*

At this stage, the teacher did not demonstrate the knowledge of the pedagogy and subject content since he did not correct the misconceptions. The teacher had the knowledge of operating the smartboard, but he struggled to integrate ICT tools into his lesson. Beside using the activity that is not at the level of the learners, the teacher missed the opportunity of correcting the inaccuracy that was observed in the lesson. The teacher should have stopped the learner from continuing and addressed the issue. The teacher only involved one learner to do the activity instead of involving all the learners, in this way, it means other learners remain passive.

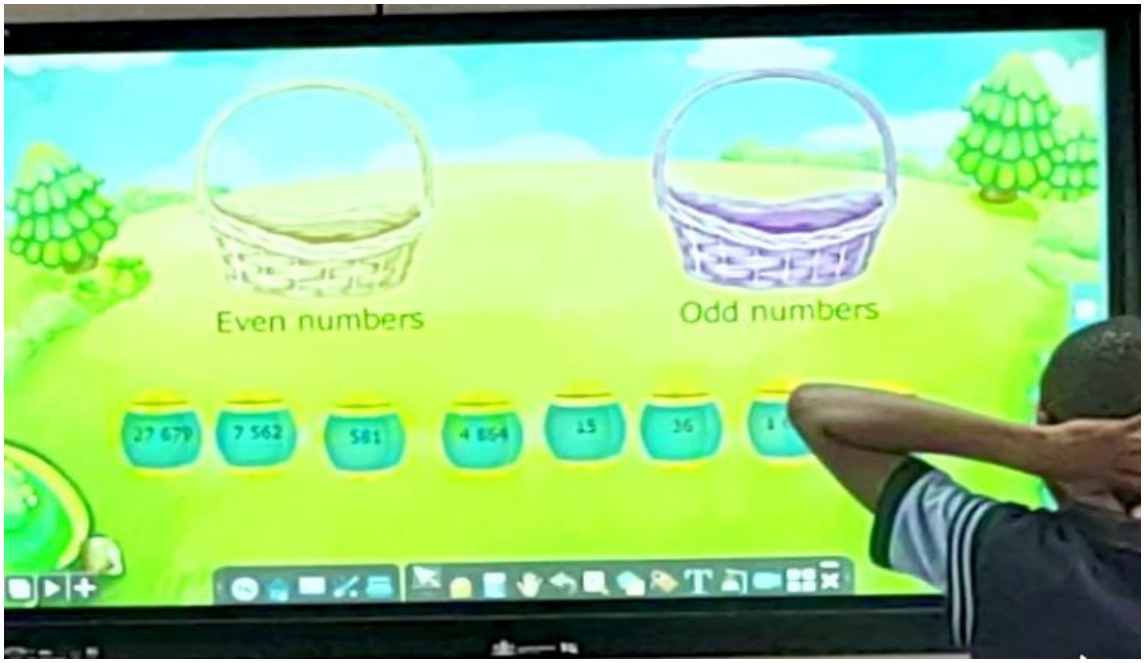
4.4.2 Sub-theme 3.2: The development of mathematical skills

To effectively teach mathematics, teachers develop mathematical knowledge using ICT tools. Mathematical knowledge and skills include subject content knowledge, selection of proper learning resources, the presentation of the lesson, the teaching environment and so forth.

ICT vs normal methods to teach mental maths

Mental maths is one of the most vital aspects of teaching and learning of mathematics, promoting quicker thinking skills. During observations, some teachers did mental maths using ICT tools while others used a traditional method.

Teacher Mary did four game-based activities focusing on whole numbers to facilitate quicker thinking. One of the activities included sorting numbers on whether they are odd or even. Teacher Solly also used the same activity to do mental maths. Following is the scenario of how the activity was conducted in teacher Mary's class.



(Source: My own design)

Figure 4.4: Mental maths activity on sorting even and odd numbers

Teacher Mary opened the activity on the smartboard and started with lesson: *"I have two baskets; I want us to come and arrange these numbers in the correct basket. We have the basket for even numbers and then for odd numbers. Who can put the correct eggs in the correct basket?"*

Learners raised their hands and one learner was chosen to sort the numbers.

Teacher Mary: *"Choose one for odd numbers and one for even numbers"*

The learner went to the smartboard and started to scratch his head symbolising that he does not know the answer.

Teacher Mary then said: "*If you don't know the answer please sit down".*

Seeing that Learner A struggles, Teacher Mary moved on and chose another learner to sort the numbers. Learner B went to the smartboard and chose 15 and inserted them in the even number's basket. The number was rejected and went back to the row of the numbers waiting to be sorted.

In disappointment, Learner B quickly went back to his seat and Teacher Mary explained what just happened: *"It's incorrect. The minute that egg goes back, it means you put it in the wrong basket. It does not belong there."* Teacher Mary's statement

shows that, with ICT, the feedback is instant and it is in the form of corrections at the same time. In this case, knowledge retention is guaranteed as learners will now know that 15 is an odd number.

Learner C then went to the smartboard; she chose 15 that was wrongly placed by the previous learner (learner B).

Other learners complained: *"Ayi…You have seen it already."*

Learners' reaction towards Learner C displays that learners are paying full attention in the activity with increased concentration towards the lesson. According to the learners, they believe that Leaner C is cheating since she just went straight to the number that Learner B failed to insert.

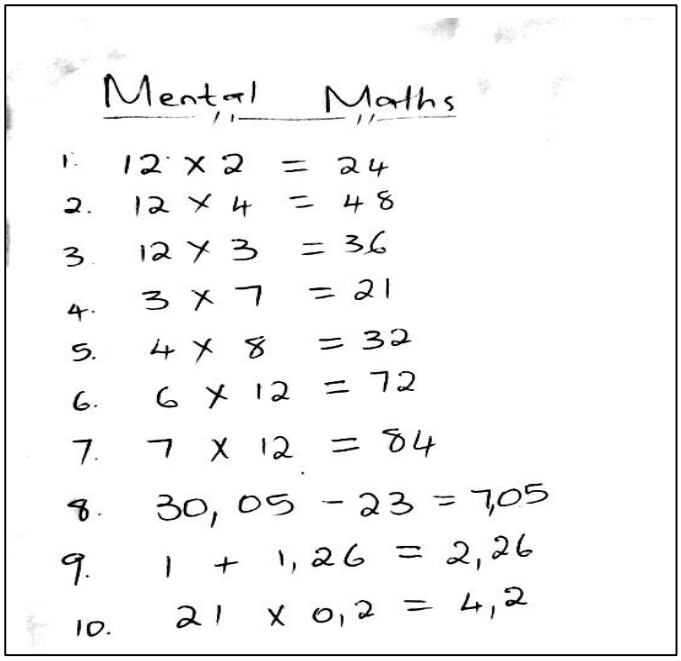
Teacher Mary*: "Learner C continue and put another one".*

Learner C attempted to insert another number, but it was rejected and went back to the row. Learners became more interested in the lesson, and it was the matter of repeating the same process. If one learner failed, then the next learner put that number in the opposite basket, but failing on the second one.

Teacher Mary: *"Ok, listen boys and girls, this is just the revision of even and odd numbers. I believe you know that the even numbers end with the number 0, 2, 4, 6, 8, so when you are choosing the eggs, you are supposed to look at the last digit. If the last digit is 0, 2, 4, 6, 8, it means that it belongs to the even numbers and the numbers that are odd the last digit is going to be 1, 3, 5, 7, 9."*

Teacher Mary's statement represents the consolidation of the lesson where she explains to the learners how to recognise even and odd numbers. The lesson indicated the interaction between the teacher and learners. Learner full engagement was observed with the teacher being the facilitator.

In contrast to Teacher Mary's lesson, Teacher Lucy adopted a traditional method to do mental maths. Teacher Lucy spelled out the sums to the learners while they copied these into their books.



(Source: Participant's creation)

Figure 4.5: Template of mental maths activity

On completion of the activity, the corrections were done orally, while learners marked their own work. After 10 minutes, the teacher and learners did corrections.

Teacher Lucy asked: *Ok, number 1, the answer is?*

Learners: *24*

Teacher Lucy: Corrections, mark your work. The second one?

Learners: *48*

Learners continued to shout the answers until the teacher heard different answers in the class.

Teacher Lucy: *Number 6*

Learners: *72, 70*

Teacher Lucy: *72, number 7?*

In this case, learners were heard shouting different answers, while others were saying 72 others were saying 70. The teacher repeated the correct answer after hearing different answers to ensure that learners marked the correct answer.

Teacher Lucy: *Number 9?*

Learners: *Two comma twenty-six, others: Two comma two six*

Teacher Lucy: *It's not comma twenty-six, but its comma two six. Correct mathematical language neh?*

Learners: *Yes*

As the lesson continued, the teacher emphasised the importance of mathematical vocabulary on how to pronounce numbers after the comma in decimal numbers. Instead of learners reading the decimal numbers wrongly, the teacher was able to immediately correct this misconception.

Teacher Lucy: *The last one?*

Learners: *0.14 (zero comma fourteen)*

Teacher Lucy: *No, raise up your hands.*

Learner 1: *4,7*

Teacher Lucy: *No, it's not 4,7*

Learner 2: *0,2*

Teacher Lucy: *No*

Learner 3: *42,02*

Teacher Lucy: *No*

Learner 4: *4,2*

Teacher Lucy: *Clap hands for her, the answer is 4.2.*

Teacher Lucy observed that learners were struggling with the last question, she then decided that learners raise their hands. Different answers were heard from learners, until one learner had the correct answer.

Classroom observation with Teacher Lucy revealed that learners do not have much control of what is happening in the classroom. They were required to find the answers to the given sums which were written in their books. This affords learners the opportunity to prove if they have developed understanding of the concepts. The teacher was able to check areas in which learners struggled and learners were able to reflect on where they struggle so that they can correct themselves.

Mental maths using the Kahoot app brought fun into the classroom and learners actively participated. There was increased learner engagement and improved

concentration. In line with this study Dahkal (2018) also said ICT integration has a positive impact on motivation. Four different mental maths activities based on numbers were completed in the lesson, showing that ICT tools are able to create more time for learning in the classroom. However, if the activity is done on the smartboard, there is a possibility that not all learners get the chance to participate in the activity. The use of smartboards, however, leaves no evidence that the activity has been done since learners do not record their answers in their workbooks. Authors such as Appavoo (2021) posit that work done by learners on their tablets is not traceable. If there is no evidence, it means learners are unable to reflect on where they struggled. Lastly, chances of identifying learners who are struggling with mental maths are very low because in cases where the number is rejected, the other learner immediately uses that number to insert it in the right category. Mental maths activities administered through ICT tools are able to create interaction in the classroom. Learners actively participate and the feedback is instant.

Conceptual understanding through videos

The use of videos enhances understanding of different mathematical concepts such as fractions and numeric patterns. During classroom observations, the use of videos to deliver the lessons was seen as a dominating method of ICT integration to teach mathematics.

Teacher Lucy presented a lesson based on numeric patterns. The lesson focused on investigating and extending patterns. Teacher Lucy wrote the topic on the board to indicate that she is about to start the lesson and the learners concentrated on the board.

Teacher Lucy: "*Today we are going to investigate and extend patterns. Can you read all of you?"*

Teacher Lucy's statement is seen as a way of getting learner's attention as she requested all the learners to read the topic on the board.

Learners: "*Investigate and extend the patterns*".

Teacher Lucy: "*So now what I'm going to do, I'm going to show you a video which will be dealing with the investigation and extending patterns*".

Teacher Lucy then went to the smartboard and opened the mySDLR app to access the video on numeric patterns from the digital content. All learners paid attention waiting for the video to start. Before the video can start, the teacher started by doing an example on the white board. She wrote the following pattern on the board:

2, 4, 6, __, __

Teacher Lucy: *"Ok, complete the pattern and tell me the rule, what will be our next number there, we have 2, 4, 6, the next number is? All of u?"*

Learners: "8"

Teacher Lucy: "After 8 what do we have?"

Learners: *"10"*

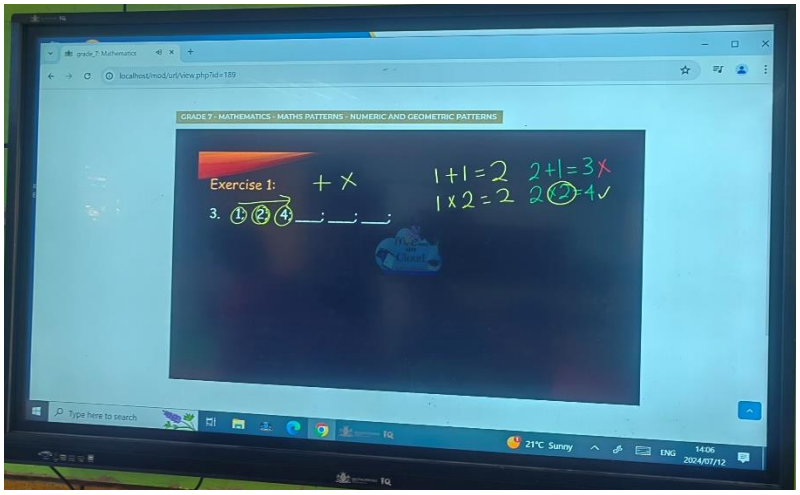
Teacher Lucy: "So what is the rule here?"

Learners: "Plus 2"

Teacher Lucy: *"It means we are adding two to get the next number"*

Teacher Lucy continued and wrote the following pattern and asked learners to complete the pattern and state the rule 2, 4, 8, 16, __, __. From this scenario, Teacher Lucy wrote on the smartboard first and engaged learners in the activity as a way of introducing the lesson. She used a problem-based approach, evoking learner's thinking skills. She also used simple patterns to ensure that learners understand the concept. This is also seen as a way of ensuring that learners who experience difficulties with number patterns are given a foundation which would assist in understanding the video.

Teacher Lucy then opened the video, which increased concentration observed in the classroom. The video explained how to extend patterns in terms of a constant difference and a constant ratio. The use of the video introduced learners to the new mathematical concepts, that is, constant ratio (multiplying or dividing with the same number to extend the pattern) and constant difference (addition or subtraction of the same number to extend the pattern). The video explained how to work out the rule, teaching learners different strategies on working out the rule of a pattern. For instance, if the pattern is growing, there are two possibilities, it is either addition or multiplication.



(Source: My own design)

Figure 4.6: The lesson on extending and investigating patterns

While watching the video of different activities play, Teacher Lucy paused the video to give learners the opportunity to find answers before the answer appeared on the screen.

Teacher Lucy: *"There it is; can you work that out?"*

Learners: "*Yes".*

Teacher Lucy: "*We have 1, after 1 we have 2, after 2 we have 4, what is the rule there?*"

Learners: "*The rule is 2*."

Teacher Lucy: "*Remember I said the rule must have a sign. Do you remember the four signs of operation?"*

Learners: "*Yes"*

Teacher Lucy: "*You must include one, you cannot say 2, what do we do with 2?"*

Learners: "*Nothing.*"

Teacher Lucy: "*Now the rule is? Yes, Learner A?"*

Learner A: "*The rule is plus 2*."

Teacher Lucy: "*Ok let us check whether its correct or not*."

1 x 2 = 2

2 x 2 = 4

4 x 2 = 8

8 x 2 = 16

16 x 2 = 32

32 x 2 = 64

Teacher Lucy then opened the video to check if the answers they calculated with the learners corresponded with the answers on the video. Teacher Lucy used the same pattern of pausing and allowing learners to work out the rule and extend the pattern throughout the lesson. This observation revealed that videos have a great influence on lesson delivery. The teacher taught learners how to work out the rule by looking at the next number but the video reminded learners that there are always things to consider when working out the rule. If the pattern increases, learners need to consider addition or subtraction, but if the pattern decreases, learners need to opt for subtraction or division. The use of the video also introduced learners to different terms of extending the pattern, that is, constant difference and constant ratio.

Teacher Brian presented a lesson based on conversion of common fractions into a percentage. He started the lesson by writing the topic on the board, and asked learners to name common fractions as a way of introducing the topic.

Teacher Brian: "*Ok now that we have identified common fractions, what we want to do is, we want to convert these common fractions into percentages. Now talking about percentages, it is something that you are well aware of, right?"*

Learners: *"Yes sir."*

Teacher Brian: "*Especially when you are writing a test, exams, you are asking yourselves what did you get. I got 50%, I got 20%, neh?"*

Learners: "Yes."

Teacher Brian: "*Now how did they get those percentages. Do you know how to get a percent? Let's say you are writing a test, the test is out of 50, they give you 20 out of 50. How many percent is that?"*

In this scenario, teacher Brian is trying to use learner's prior knowledge of percentages. He presents to the learners with a real-life situation of percentages so that learners have an idea of where fractions apply in real life. Teacher Brian then

wrote 20/50 on the board and asked learners what the answer is. Learners argued saying the answer is 40 while others said the answer is 45. The teacher intervened.

Teacher Brian: *"You are saying 40, you are saying 45, how did you get that 45?"*

Teacher Brian's questioning led learners to find the strategy to convert 20/50 into a percentage.

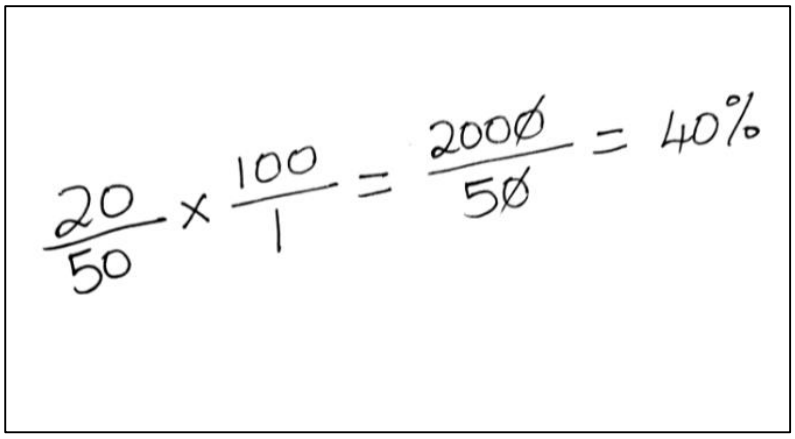
Learner A: By dividing 20 into 50.

Teacher Brian: Ok, how did you get the 40?

There was no response in the classroom and the teacher then started to introduce the procedure that learners are supposed to use to convert a fraction into a percentage. Teacher Brian explained the following method to the learners.

Teacher Brian: *"To convert that, you can multiply by a hundred. Yes, just multiply by hundred".*

Figure 4.7 illustrates the procedure that learners were taught.



(Source: My own design)

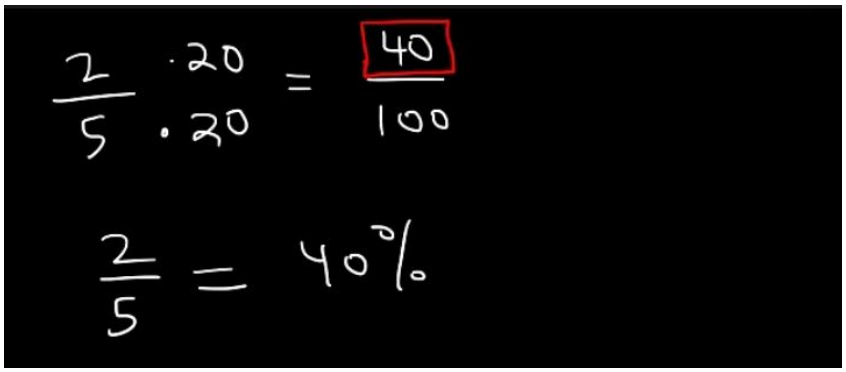
Figure 4.7: Method to convert fractions to percentages

According to Teacher Brian, learners can convert the common fraction by simply multiplying the fraction by 100. However, the observer had a concern if learners really understood what a percentage is, and if they would be able to make a connection between conceptual knowledge and procedural knowledge.

The teacher then continued with the lesson and opened a video.

Teacher Brian: *"Ok here we go. I want to show you a video on how to convert fractions into percentages. Ok I'm just going to play this short video."*

The video introduced learners into a new method of converting a fraction into a percentage, which is simply converting a denominator into a hundred, through multiplication.



(Source: My own design)

Figure 4.8: Conversion of fractions to percentages from the video lesson

The teacher then paused the video and asked the learners.

Teacher Brian: *"I don't know if you heard what is said there?"*

Learners: *"No sir, please repeat the video again."*

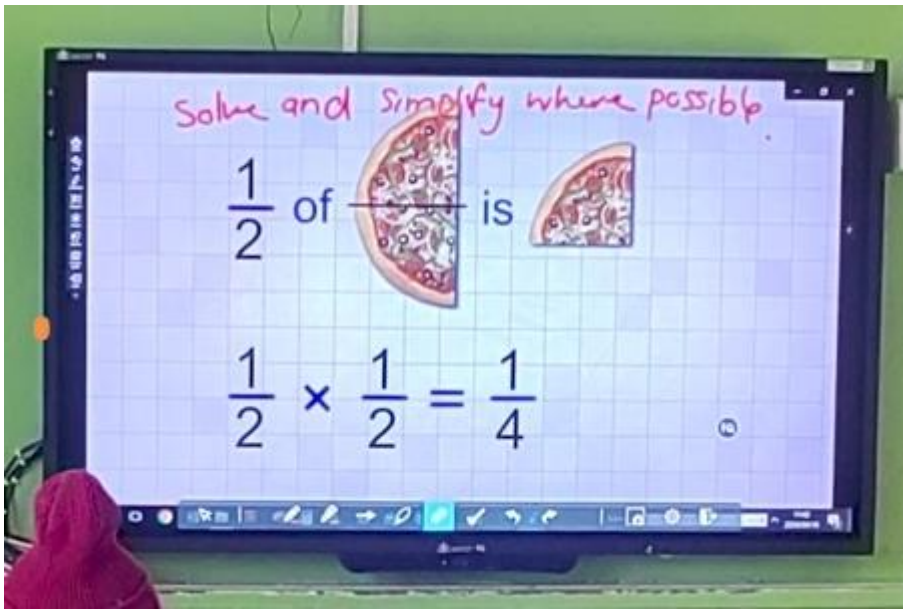
Teacher Brian*: "I can repeat what he is saying. You have 2/5, now you want to convert 2/5 into a percentage … right?"*

Learners: *"Yes."*

Teacher Brian*: "So what he did was, he looked at 5 the denominator, and said how can we turn that denominator into 100. Any number over 100, you can just put that number as a percentage. For instance, 10/100, you can just say 10%, 20/100 is 20%, 17/100 is 17%, 30/100 is 30%. Any number that is over 100, that number is a percentage."*

Teacher Brian missed the opportunity to explain to the learners what a percentage is. The video stepped in and explained to the learners what a percentage is, which is basically over 100. Through this definition, it made more sense to the learners to understand how to convert. In this lesson, the video introduced learners to a better understanding of what a percentage is and it also provided learners with a much better procedure to convert.

Teacher Irene presented a lesson on multiplication of fractions. She introduced the topic by explaining how to multiply as simply multiplying the numerators separately and multiplying denominators separately and simplifying. She then opened the video which used the same method and went on to clarify the multiplication of fractions in terms of calculating the fraction of a fraction.



(Source: My own design)

Figure 4.9: Presentation of calculation of a fraction of a fraction

The video explained this concept using half a pizza slice, and then took away half of the half pizza resulting in a quarter. This means that half of the half is a quarter. This lesson revealed the power of the video in terms of clearly demonstrating concepts that the learners might have found difficult to understand.

Teacher Irene: *"Ok he is talking about the word "of".*

Learners whispering: "*Division."*

Teacher Irene: *"He is introducing something else now, he is saying the "of" means multiplying. I'm finding three thirds or three quarters of one whole of a pizza. If I have a full pizza and I'm finding three thirds of that, how many pieces of that? Three quarters of a whole, exactly as I'm saying it, what is three quarters of a whole, "of" I'm multiplying, what am I multiplying 1 x ¾."*

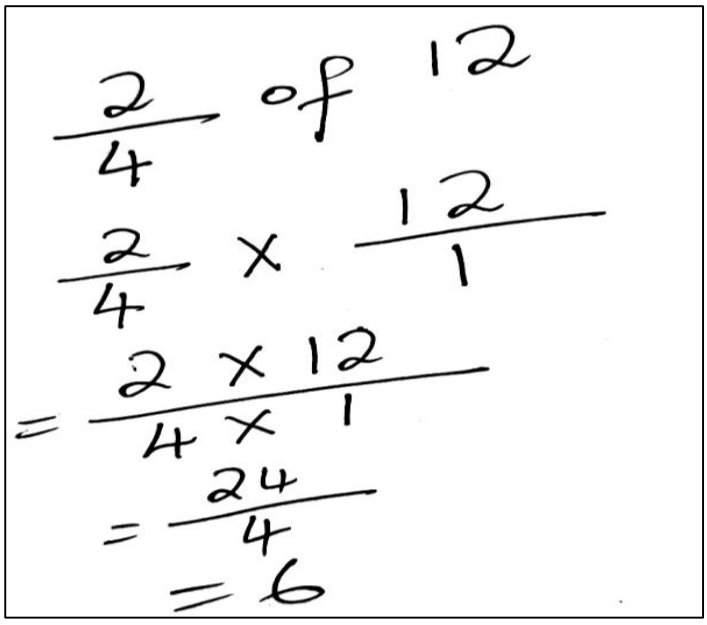
Teacher Irene then gave learners a problem to check if they understood the concept of ‘of’ in multiplication of fractions.

Teacher Irene: *“12 girls attended assembly today. Two quarters of them were sitting were sitting. How many girls were sitting down?”*

Learner: *“Ma’am 6”*

Teacher Irene: *“Good”.*

Teacher Irene then went on the board and explained how the learner got the answer 6. Figure 4.10 illustrates the method she used.



(Source: My own design)

Figure 4.10: Method of calculating percentage of a whole

Teacher Irene: *“2 over 4, and we said ‘of’ is what?”*

Learners: *“Multiplication”*

Teacher Irene: “*And what I have learnt today is that I can multiply in any order, what is this twelve sitting over?”*

Because 12 is written as a whole number, not as a fraction, Teacher Irene asked learners what is twelve sitting over indicating the numerator and the denominator.

Learners: *“1”*

Teacher Irene: *“So 2 x 12 over 4 x 1. 2x 12 equals?”*

Learners: *“24”*

Teacher Irene: *“4 x 1= 4 and the answer is 6.”*

Firstly, the teacher introduced learners to the concept of multiplication of fractions, but through the use of the video, the teacher managed to teach two concepts at once. The video further explained the concept of finding the fraction of a fraction and the teacher saw an opportunity since the two concepts use the same procedure to calculate. This is proof that the use of videos to teach mathematics reduces the time spent on a topic, while allowing teachers extra time to work with learners who are struggling.

The use of videos has been seen as a dominating ICT tool that teachers use as their method of integrating ICT to teach mathematics in this study. Teachers are able to use the videos in an effective way. They do not expect the videos to do the work for them, but they are able to use it as an extension of learning resources. In Teacher Lucy’s class, the video assisted the teacher in explaining how to extend patterns using constant ratio and constant difference. In Teacher Brian’s class the video assisted the teacher through revealing the alternative method which linked conceptual knowledge and procedural knowledge. In Teacher Irene’s class, the video assisted the teacher by clarifying the concept in terms of the picture and also combining two subtopics that use the same procedure to work out the answers. Authors such as Engelbrecht et al. (2020) confirmed that videos have the power to reveal new mathematics in the classroom, providing different modes such as image, language, music and gesture. Videos are able to enhance the understanding of mathematical content and concepts. Engelbrecht et al. (2020) attest that through videos, learners easily understand the content and they are able to identify challenges and work on them on their own. Most importantly, teachers also ensured that the videos are not long to ensure that learners are don’t concentration.

4.4.3 Sub-theme 3.3: Learners’ reactions to the lessons

The use of ICT tools during teaching and learning of mathematics raises learner’s interest towards the lesson. The following scenario is the presentation of how learners reacted in Teacher Lucy’s class, teaching the investigation and extension of the numeric patterns. Teacher Lucy opened the video with an incomplete pattern, she

paused the video and instructed learners to find the rule and complete the pattern. This is the pattern that appeared on the screen:

729, 243, ___, 27, ___, ___

Teacher Lucy: *"Ok we have 729. Our term 1 is 729, second term is what?"*

Learners: *"243"*

Teacher Lucy: *"We want to know the third term. Check the rule there. Remember last time we did the cube numbers and squared numbers. I am waiting for you to tell me the answer."*

Learners looked puzzled as they saw bigger numbers but they started working out the rule. Teacher Lucy noticed that learners were puzzled, she decided to give them a clue, she uttered:

Teacher Lucy: *"Try and work it out. We have squared numbers; we have cubed numbers. If you can check on the board, are they cube numbers or square numbers?"*

Learners: *"Cubes"*

Teacher Lucy: *"Yes, go check the cube numbers you will get the correct answer."*

Teacher Lucy kept on moving around to ensure that all learners were working out the rule and she kept on encouraging learners to try.

Teacher Lucy: *"Work it out, what do we have before 27? Or what is our rule there?"*

Learner A: *"divide by 8".*

Teacher Lucy: "*No. 729 divide by 8 is 243."*

Learner B*: "Divide by 9"*

Teacher Lucy: *"729 divided by 9 is what? Divide and tell me the answer, if the answer is 243 you will be correct, but I don't think so. Yes, learner C?"*

Learner C: "*Divide by 3"*

Teacher Lucy: "*We divide by 3. A smiling clap for her."*

Learners applauded the learner who got the rule correct.

Teacher Lucy: "*We divide by 3. How many times does 3 goes into 729, its 243 times, neh?"*

Learners: "*Yes.*"

Teacher Lucy: *"Now how many times does 3 goes into 243?"*

Learners continued to work out all the missing numbers on the board. Teacher Lucy continued to facilitate the lesson until the pattern was completed. Teacher Lucy then opened the video to check if the answers corresponded with that on the video. All learners looked very happy and applauded themselves as they were able to work out the answers that corresponded with those on the video. Learners could not wait to do another exercise to prove that they could actually do what the person on the video was doing. From the learners' reactions it seems that learners enjoy the use of technology as it helps them with their learning and motivates them to find the next solution. In this way, videos bring interest and fun in mathematics if they are used effectively.

Teacher Brian presented a lesson on conversion of common fractions into a percentage. He taught learners the method of simply multiplying the fraction with 100, as illustrated on Figure 4.10 above. Learners sat quietly without any positive response. Teacher Brian then changed the scenario and played a video on the related content.

Teacher Brian: "*I'm going to play a video on how to convert fractions into percentages".*

The video introduced the method of converting the denominator into a hundred, through multiplication, as illustrated on Figure 4.8 above. After few examples, the teacher then stopped the video and asked learners to come to the board to work at finding the solution.

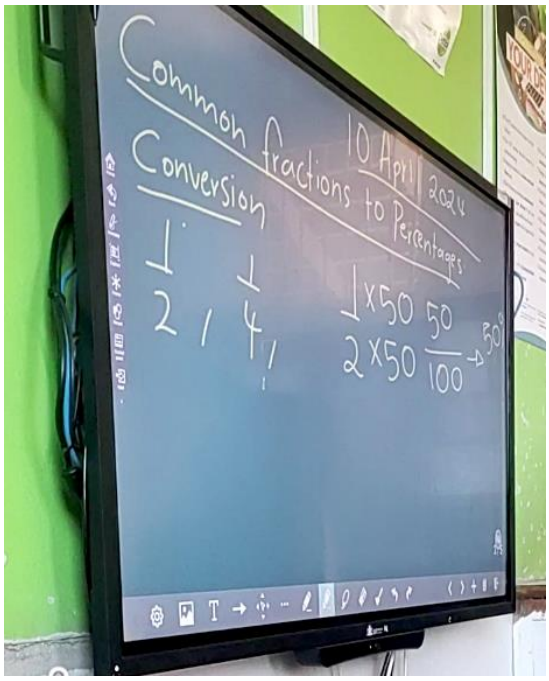
Teacher Brian: *"We have ½ and ¼, how do we convert those into a percentage, tell us, how do we convert a half into a percentage?"*

Learners eagerly raised their hands to be chosen to come to the board to do the conversion.

Teacher Brian: *"You can come to the front and do it".*

The learner came to the front with confidence and solved the problem. The learner used the method that was displayed on the video. The teacher did not specify to the

learners which method to use, but the learner applied the method that was viewed on the video. This illustrates that videos play a huge role in building conceptual understanding. Learners than applauded the learners who found the solution without any instruction from the teacher. This behaviour illustrates that learners were paying full attention and were able to tell if the other learner was correct, as presented in Figure 4.11.



(Source: My own design)

Figure 4.11: Conversion of common fraction into percentages

Teacher Brian: *"Ok guys. To identify that in order to get hundred, you have to multiply 2 by what?"*

Learners: *"50".*

Teacher Brian: "*Right. So, what you do to the bottom you do to the top.*"

While teacher Brian was busy explaining how the procedure was carried out, one learner interrupted him and said:

Learner: "*Sir"*

Teacher Brian: *"Yes".*

Learner: *"Can I do ¼?"*

Teacher Brian: "*Yes, you can come and do ¼."*

The learner volunteered to come to the board to do the activity. This shows the confidence that the integration of ICT tools promote amongst the learners. The learner's reaction shows the interest that ICT builds in the classroom. The learner came to the board and did the calculation correctly and once complete, all learners clapped hands again without the teacher's confirmation that the answer was correct.

This scenario illustrates that the video played a major role in enhancing the understanding of the content. Learners paid full concentration to the activity as they were able to tell whether the learner on the board was correct or not. This means that learners are able to identify any errors in the calculations.

4.5 THEME 4: GRADE 7 TEACHER'S PERSPECTIVE ON THE USE OF ICT IN MATHEMATICS CLASSROOM

During the process of data collection, a focus group interview was conducted to understand teachers' perspectives regarding the use of ICT in the mathematics classroom. Four sub-themes, guided by the criteria of the theoretical framework of this study, emerged from the analysis. These sub-themes include performance expectancy, effort expectancy, social influence and facilitating conditions.

4.5.1 Sub-theme 4.1: Performance expectancy

Performance expectancy advocates that an individual adopts and uses the system if it improves and makes their job easy, with observable outcomes. Performance expectancy looks at the effect of visualisation on lesson delivery and learners' active participation and concentration.

The Effect of visualisation on lesson delivery

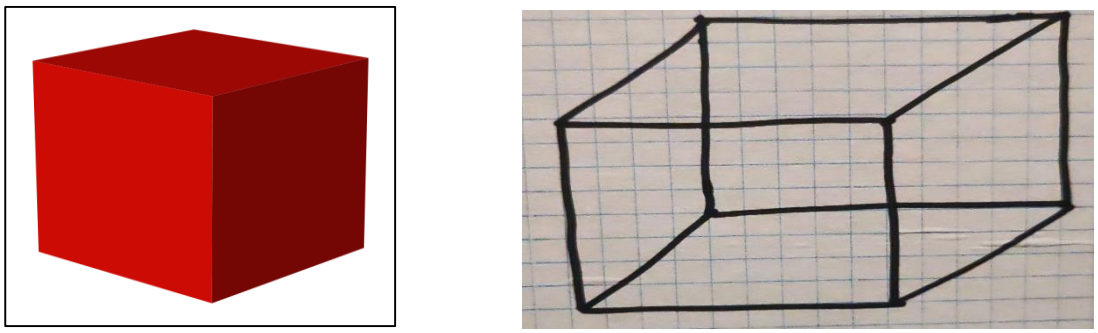
Visualising objects is an important skill that is not used in the talk-and-chalk method, that is, drawing the objects on the board. Many misconceptions and poor delivery of content can be observed if objects and shapes are drawn inaccurately. Visualisation has a positive effect on the teaching and learning process which influences teachers to accept technology.

Teachers Andrew and Victor had the same opinion regarding the visualisation of shapes during the delivery of the lessons:

Teacher Andrew said: "*it allows me to allow learners to visualise or to see the visuals of what we are trying to teach them. For example, when it comes to shape, they can actually see the shapes, they can see how they are manipulated".*

Teacher Victor said: *"Let's say you are delivering a topic of shapes, 3D shapes, it makes it easier for them to even see the shape that we are talking about other than when you drawing. Sometimes you find that some of us we are not good in drawing shapes. So, if you use ICT, it makes it easier for them to actually see the shape that you're talking about".*

Teachers Victor and Andrew believe the use of ICT tools makes it easy for them to deliver the lesson because they are able to bring in the element of visualisation which is very important in mathematics. They emphasise the issue of using the ICT tools so that learners can see the actual shapes and see how they are manipulated. Teachers think ICT brings accurately drawn shapes other than when they themselves draw the shapes on the board. Figure 4.12 illustrates an image of a cube and an image of a free-hand drawing of a cube.



(Source: My own design)

Figure 4.12: Presentation of a cube using ICT tools and drawn in freehand

When drawn on the board, not all learners can actually see what this is, but with ICT tools, it is quite clear and it can be easily manipulated so that learners can view all the sides.

While Teachers Andrew and Victor see the importance of visuals as being able to facilitate understanding of concepts, Teachers Mary and Solly see visuals as an aspect that helps to accommodate all the learners in the classroom.

Teacher Mary said: *"it incorporates different learning styles; we can be able to accommodate learners with diverse learning styles. It helps as well the development of conceptual understanding of the concepts that we will be teaching. Like other learners, they learn visually, others with hearing."*

Teacher Solly said: "*So now even through the visual, the visual ones they learn best so they can remember and when you assess them, improvement is there. I think now, in ICT, we reach all the sights, all the time and I call, all their senses, those who are hearing, visualising abstract, so we reached them*."

Teachers Mary and Solly believe that ICT is able to accommodate different learning abilities in the classroom through the use of visualisation. Administering lessons that are based on ICT are able to accommodate learners who learn best with visuals, audio and so forth. In this way the inclusivity aspect is included in the lesson.

In this study, teachers believe that ICT enhances their job performance since it facilitates the delivery of their lessons. From the teachers' views, it is evident that ICT facilitates learning when delivering mathematics lessons. It facilitates mathematical conceptual understanding since it allows learners to better view the objects. The study conducted by Graham et al. (2020) also proved that performance expectancy has a positive effect on teacher's use of ICT since teachers believe that ICT integration improves their teaching performance. The findings of this study correspond with the hypothesis of the theoretical framework (UTAUT) of this study as it states that individuals who believe that the system improves their job performance and yields better results, easily accepts the new system (Venkatesh et al., 2003). With use of ICT tools, teachers spend less time trying to explain the concepts and learners grasp the concept more readily.

Active participation and concentration

During the talk-and-chalk method, learners become passive receivers of knowledge while the teacher does a lot of talking trying to explain to the learners. With technology, learners take full charge of the lesson while socially creating their own knowledge.

This theme aims to discuss the impact of learner participation and grasping of the concepts on teachers' acceptance of technology as a new system to teaching and learning of mathematics.

Teacher Solly said: "*Learning is not becoming a one way, learners get mostly involved in the activities, more especially when we do class activities. So, the learners they all, all learners, they want to, show that they understand so that gives you as a teacher a way or it shows you where you can see easily where the learners need some assistance, which means the learners are also involved so they focus and concentrate".*

Teacher Mary said: *"It encourages active learning in the classroom, it is not most teacher-centred but it is more learner-centred with the activities that we are doing in class, and then the learners as well they show interest when we are using ICT when we are teaching".*

From Teachers Solly and Mary's statements, it is evident that learners actively participate during the activities. The lessons become learner-centred while the teacher becomes the facilitator. Learners go all out to prove that they can do the activities, which is the sign of active engagement. Active engagement also enhances collaboration between learners and the instructor.

Teacher Lucy said: *"What I have observed is that learners participate actively when you involve ICT in your lesson and they concentrate.".*

In agreement, Teacher Victor said: *"Using ICT grabs learners' attention. So, it just makes the lesson to be interesting".*

Teachers Lucy and Victor believe that when using ICT tools, there is increased concentration and active participation. The use of ICT tools facilitates the process of holding the learners' attention during the delivery of the lesson. When using the talk-and-chalk method, there are times whereby the teacher faces the board writing notes while learners lose concentration, but when using videos, learners pay full attention.

Teachers believe that ICT integration facilitates the teaching and learning process because learners actively participate and remain engaged. Learners' full concentration and participation implies that teachers are unlikely to spend time trying to get the

attention of the learners or trying to call learners into order, as normally happens with the talk-and-chalk method. Learners participate actively when lessons involve ICT. This study aligns with the UTAUT theory since it states that performance expectancy influences teachers' acceptance of the system. The study conducted by Pultoo et al. (2020) also proved that performance expectancy has a positive influence on teachers' use of ICT in the classroom. In contrast, the findings of the study conducted by Ab Jalil et al. (2022) proved that performance expectancy has no effect on teachers' behavioural intention to use ICT.

4.5.2 Sub-theme 4.2: Effort expectancy

Effort expectancy is defined as measuring the ease of the use of the system (Venkatesh et al., 2003), in this case, integrating ICT in the teaching and learning of mathematics. Teachers tend to use ICT tools in a number of ways during the teaching of mathematics:

Teacher Andrew stated: "*Okay, from a personal perspective, I find it pretty simple and easy to use, right? But remember, again, you have to be able to prepare, it doesn't mean that you have a device, you just go into class, and you start presenting, obviously, you have to prepare".*

Teacher Victor gave the similar comment: *"I want to say when it comes to ICT myself personally, I do find it easy, but again, there is some sort of preparation that needs to be involved in the background".*

Teachers Andrew and Victor both acknowledged that, for one to experience the ease of integration of ICT, there needs to be proper planning and preparation. For instance, if a teacher intends to use a video to support a lesson, it is important to watch the video first to ensure that it is the right content, to check if there are any misconceptions, also to ensure that the length of the video will not have a negative impact on the lesson as learners tend to lose concentration if the video is lengthy.

Teacher Mary said: *"Yes, I can also say it is easy to use, it just requires planning and as well to have knowledge of what to do you know, with this ICT, actually ICT skills, that's what you need to have as well."*

Teacher Mary's statement also emphasises the importance of planning and preparing the lesson, but also stressing the importance of ICT skills in order to integrate ICT in the classroom. If teachers do not have necessary ICT skills, it is highly possible that they will find it difficult to integrate ICT during teaching and learning of mathematics.

Teacher Lucy also stressed the importance of planning: *"I can say not, it's not that easy, but you need to plan. If you have planned, it will be easy for you to use"*. Teacher Lucy's statement is also in agreement with other participants, she also believes that proper planning is the key to effective integration of ICT in mathematics.

Authors such as Hero (2020) confirm that ICT integration is a complex process as it requires intensive planning and preparedness so that it is effective. In this study, teachers believe that it is easy to use ICT tools, particularly if one has knowledge of and training in the use of technology, but they emphasised the need for proper planning. Effort expectancy has a significant influence on teacher's behaviour to use ICT. This study aligns with that of the study conducted by Bandoh et al. (2024) who discovered that teachers are influenced by the ease of integrating ICT in their lessons. In contrast, Ab Jalil et al. (2022) discovered that effort expectancy has little or no effect on teachers' behaviour to use ICT. Similarly, the study conducted by Paltoo et al. (2020) concluded that effort expectancy has no significant impact on mathematics teachers' use of ICT.

4.5.3 Sub-theme 4.3: Social Influence

Social influence is the degree to which an individual's use of the new system depends on the perceptions of important people around them (Venkatesh et al., 2003). This implies that mathematics teachers tend to use ICT tools if influenced by their colleagues or by their seniors. If teachers are encouraged to integrate ICT, it is likely that they will actively incorporate ICT in their lessons.

The influence of principals in ICT integration

Principals play a vital role in ensuring the implementation of technology in the classroom through the development of an ICT policy which is a blue print for the school to design and manage ICT for teachers and students in a systematic and progressive manner. The role of school management is to provide strategic vision, guidance, and support to ensure effective integration of technology into teaching and learning.

Teacher Andrew said: *“Okay, so we are lucky that our principal does want us to use ICT in the class. Whenever there's ICT coordination meetings and MST meetings that involves ICT, she does avail herself, in fact, to the extent where she actually also attends a lot of teams meeting, right. And she also has, so the fact that she has the ability to do that by herself. It means that she's that she embraced ICT for our own for, our own use”*.

Teacher Andrew’s principal is knowledgeable about technology devices as she attends virtual meetings without asking assistance from other colleagues. She is portrayed as an individual who attends ICT training meetings with the teachers, as this will also encourage teachers to attend these meetings, which eventually benefit and encourage them to integrate ICT during instruction. The fact that the principal is showing great interest in ICT, teachers also recognise the importance of integrating ICT in the classroom.

Teachers Lucy and Solly agree that the school management, specifically the principal, promotes the use of ICT by ensuring that the challenges that hinders the process of ICT integration are attended to immediately. Teacher Lucy said: *“Our school principal is very interested and they encourage us to use ICT on daily basis. They will go around checking whether we are busy with it or if there are problems they try and fix them, even though some are beyond their control but they are there for us”.*

The school management provides support in integrating ICT tools in the classroom. They monitor the use of ICT tools by moving around the school during contact time to ensure that all teachers are integrating technology with ease to enhance teaching and learning. Leaders also ensure that the process of integrating ICT runs smoothly by attending to the challenges that teachers encounter in the classroom.

Teacher Mary: *“The management are also trying that the teachers have laptops and everything they need in their classrooms”.*

School management, which includes the principal, ensures that all the teachers have the right infrastructure necessary to integrate ICT during teaching and learning. These include teacher’s and learner’s laptops, well mounted smartboards, the internet and so forth.

Leaders play a vital role in ensuring that ICT in their schools is effectively integrated. In the participating schools, teachers commended the support they receive from their leaders. The fact that their leaders are able to use ICT tools encourages teachers to use ICT tools in the teaching and learning process. Teachers are influenced to integrate ICT in mathematics because their leaders encourage them and they receiving the required support to overcome any challenges. Authors such as Barakabitze et al. (2019) also advocate for such as they posit that effective leadership is the core element of successful acceptance and adoption of technology in education. Similarly, Graham et al. (2020) attest that leaders play a significant role in influencing teachers to use ICT to support their lessons. This study's findings also align with the original hypothesis of the UTAUT framework which recognises leaders as the facilitating conditions for ICT integration.

Influence of colleagues

The use of ICT tools is not only enhanced by the school management, but colleagues too, play a vital role in influencing other teachers to use ICT tools. If other teachers use ICT in the classroom, it builds a positive attitude to other teachers to use ICT tools as well.

Teacher Lucy said: "*Yeah most of them are using ICT, those who think they cannot do it, they ask those who are sharing with them the learning areas to help them. But yeah, we are encouraged to use it on daily basis".*

Teachers provide support for each other to ensure that ICT integration is effective. This statement also marks the future of ICT integration in the teaching and learning process. Even though teachers have not received training on ICT integration specifically in a particular learning area, through sharing and helping one another, they are able to share the software that could be integrated during teaching and learning, especially in mathematics.

Teacher Andrew stated: *"In terms of educators using ICT, I have seen some maths, some science, some technology educators using the ICT, as soon as the laptops got to them"*.

Teacher Mary said: *"Yes, ma'am. In my school all Grade 7 teachers are encouraged to use ICT".*

Teacher Solly maintained: *"The other educators, most, the Grade 7 educators are involved in ICT integration, even on the smartboard … their textbooks are there and they use it"*.

Teacher Victor said: *"Our colleagues, yes, whenever I move around, I normally see them using ICT more especially now that our smartboards they have downloaded the textbooks".*

The above statements show the level of ICT use in schools. Teacher Andrew revealed that it is not only maths teachers who are using ICT tools; teachers have fully taken part in using technology in other subjects as well, and are embracing the change brought about by ICT tools. Teachers Solly and Victor indicate that teachers are breaking away from hard copy textbooks and they are using e-books that are installed on the smartboards. This shows that teachers have accepted technology and they have a positive attitude towards its integration in lesson delivery.

The results of this study align with the theoretical foundation of the theory of this study, the UTAUT theory. There is a strong influence of colleagues in teachers' use of the technology. This study aligns with that of Graham et al. (2020), Paltoo et al. (2020) and Ab Jalil et al. (2022), who posit that other teachers play a vital role in influencing teachers to integrate ICT in teaching and learning. Similarly, the study conducted by Bandoh et al. (2024) revealed that the colleagues of the participants have a positive attitude toward the use of technology, and they assist each other and share information and this behaviour motivates and encourages them to use technology to teach. In support of this finding, Bandoh et al. (2024) believes that negative effect of social influence can lead to discouragement on ICT integration in mathematics instruction.

4.5.4 Sub-theme 4.4: Facilitating Conditions

Facilitating conditions are described as a belief an individual has on the system based on the existence of necessary facilities to enhance someone's job (Venkatesh et al., 2003). In this case, these facilities involve smartboards, laptops, electricity power, internet connectivity, mathematical software.

Availability of ICT resources

The influence of facilitating conditions on teacher's acceptance of technology needs to be considered.

Teacher Andrew said: *"Yes, our facilities are actually quite … if I'm going to use the word, I think it's quite impressive that some of us especially in Grade 7, there is the internet, teachers have got the laptops, there is smartboards, and we should be actually using it much smoother so the facilities actually help, so I am actually impressed with facilities that we have".*

Teacher Andrew commends the availability of ICT facilities and infrastructure in their school, especially in Grade 7. With the availability of the ICT tools teachers are motivated to use ICT tools. Teacher Andrew believes that the process of ICT integration is facilitated with the necessary resources.

Teacher Lucy said: *"This one, because each and every learner has got a laptop, they have to do something from their laptops, they have to do something from the smartboard. So always it encourages to integrate the lesson through ICT".*

Teacher Lucy is motivated to use the ICT tools because learners have laptops so learners are able to work or do activities on them. The availability of smartboards allows teacher the opportunity to engage learners on the activities that are done to enhance the teaching and learning of mathematics.

Teacher Victor said: *"Fortunately, with our school, I would say all the facilities are there to assist us in integrating ICT. Learners, they have their laptops teachers have laptops, we have internet and smartboard. So yeah, I would say I don't have any excuse to say I am not using ICT".*

The availability of ICT facilities in the classroom motivates Teacher Victor to confidently integrate ICT tools during content delivery. There is no justification for not integrating ICT because schools have all the necessary facilities to adopt technology.

Teachers Mary and Solly had the same argument, yet raised concerns regarding connectivity:

Teacher Mary said: *"Yes, ma'am on my side as well, with regard to ICT resources, we all have, teachers all of them in Grade 7 do have laptops, learners have their tablets,*

even the smartboards, they are installed properly, all the textbooks and the software which you want to use, the only challenge which we have is the Wi-Fi connection, however I normally connect my learners using my Wi-Fi, yea, and we also have the back up when there is load shedding".

Teacher Solly said: "*All the learners in Grade 7 they have their tablets on daily basis and I as an educator I have my laptop and the smartboard, but now the challenge is the connection, some of the videos or some of the games that you want to put in the lesson, so they can't view it just because there is no connection unless you use your own, so that is the challenge but otherwise, they got the facilities. The facilities are there, is only the connection that is a problem*".

Teachers Mary and Solly acknowledged the availability of ICT tools in their schools including the back up when there is load shedding. The challenge raised relates to concerns about accessing the internet; however, teachers resort to using their own data to ensure the teaching and learning with ICT proceeds. This could have a negative impact on teachers as they end up using their personal data which should be provided by the school.

In this study, facilitating conditions have a significant impact on the influence of teachers in using technology. Participants indicated that they have necessary facilities such as well mounted smartboards, laptops and internet connectivity. This study aligns with original foundations of the theory of Venkatesh et al. (2003) as it states that the facilitating conditions of any system positively influence the user behaviour of any individual to accept and adopt that system. Similarly, Ab Jalil et al. (2022) discovered that facilitating conditions have a positive impact on teachers' use of ICT tools and Paltoo et al. (2020) and Bandoh et al. (2024) also found that the availability of ICT tools play a significant role on ICT integration during teaching and learning.

Accessibility of ICT tools across all primary grades

Although teachers acknowledge the availability of ICT tools in Grade 7, they did raise concerns about how the accessibility of ICT tools in other grades.

Teacher Andrew said: "*So basically, I feel that the GDE needs to actually allow all the Grade 4, 5 and 6 mathematics educators, also allow them to have devices and*

smartboards in their classes. Because they need to allow for sustainability because right now what's happening in the primary school is that learners are coming from Grade 4,5 6 using the traditional method and when they come to Grade 7 and all of a sudden they are being introduced to ICT"

Teacher Solly said: *"ICT integration, it should have started when the learners getting into the Intermediate Phase in Grade 4, then go through. Now they are doing ICT integration in Grade 7"*

Teacher Victor said: *"I think if it starts from the lower grades until, by the time they get to Grade 7 they fully know how to use the ICT so I think if the GDE or even schools can put more funding and then make sure that all the classes and the teachers they do have ICT, they do use ICT in their classes."*

Teacher Mary also voiced a similar concern suggesting that technology should be implemented across all grades. ICT is only available in Grade 7 classrooms where teachers have laptops and smartboards in their classrooms. Learners in Grade 7 also have access to laptops. Teachers are concerned about the sustainability of ICT and how it affects them if ICT tools are only available in Grade 7.

As ICT tools are only available at Grade 7 level, this implies that the application of technology in primary school is limited. This poses a challenge as Grade 7 teachers, who teach other grades, need to switch from conventional methods of teaching to modern methods of teaching (ICT integration) from time to time. Primary school learners, when entering Grade 7, may be challenged in adapting to a new system at a very later stage. One of the challenges is going off task during teaching and learning. Meinokat and Wagner (2022) believe that the main reason for learners going off task is lack of self-discipline and self-regulation. Learners become too excited that it might be difficult to discipline them in class and as a result, teachers might feel frustrated and refrain from allowing them to use their laptops during teaching and learning. This is supported by the data collected through observations, only three out of seven educators allowed learners to use laptops. Those who allowed them encountered challenges of learners being unable to navigate to required sites, while most of them opted for playing games during lessons. To avoid disruption in the classroom, Meinokat and Wagner (2022) suggested that teachers need to put clear guidelines in

place in terms of what is appropriate or not, when using digital tools. This is proof that learners are only competent if they are doing their own things like playing games and taking pictures, but they struggle with navigating through educational sites.

4.6 CHAPTER SUMMARY

This chapter presented the findings of the study based on understanding the integration of ICT in the teaching and learning of mathematics. Observations revealed that teachers are willing and they do integrate ICT tools, but they have limited knowledge on the meaning of integration of ICT in mathematics as a subject and lack in-depth skills to effectively integrate ICT to teach mathematics. They were seen using PowerPoint, videos and game-based activities. However, many lessons were teacher-centred. Teachers use the knowledge they acquire from the training they receive and use it in mathematics.

Semi-structured interviews revealed benefits and challenges. Benefits included active engagement, easy way of delivering the lessons, extra time allowing space for intervention. Lack of ICT knowledge, lack of connectivity and poor network connection were the challenges. Social influence is a strong predictor of the behavioural intention to use ICT particularly when the school is well-equipped with technology tools, school principals encourage its use and colleagues support each other in its use. Teachers find it easy to use ICT tools but proper planning is needed for it to be effective. Teachers have the necessary facilities to integrate ICT but they complained about the issue of connectivity. Considering the findings, the adopted theory (UTAUT) proved to be the right theoretical framework for this study as it provided a lens for viewing the findings. The following chapter presents the summary of the findings, offer recommendations and draw conclusions.

CHAPTER 5: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

This research study has been driven by the aims and objectives that underpin this study. The aim of this research was to investigate the ICT integration to teach Grade 7 mathematics in the Johannesburg East District.

The study's goals were as follows:

1. To investigate the pedagogical benefits of integrating technology in Grade 7 mathematics classrooms.
2. To explore the challenges in implementing technology in Grade 7 mathematics classrooms.
3. To develop understanding of how ICT is integrated in Grade 7 mathematics classrooms in the Johannesburg east district.
4. To investigate Grade 7 teachers' perspectives on the integration of ICT in their mathematics classroom.

This chapter summarises the findings, in accordance with the questions that aligns with the aims and objectives of this study. This chapter also draws the conclusion on the findings of the study. This chapter also offers recommendations and suggestions for future studies as well as presenting the limitations and delimitations.

5.2 RESEARCH FINDINGS

To answer the questions of the study, classroom observations, semi-structured interviews and focus group interviews were conducted. This section discusses the findings of the study in accordance with research questions, using the main themes that emerged from the findings. The research findings attempted to answer the research questions.

5.2.1 What are the pedagogical benefits of integrating technology in Grade 7 mathematics classrooms?

Two themes were developed from the findings which gave insight into the pedagogical benefits of incorporating ICT to teach mathematics, enhancement of understanding of

different mathematics content areas and the impact of ICT on learners' concentration and academic improvement.

5.2.1.1 Enhancement of understanding of different mathematics content areas

The findings revealed that integrating ICT tools in the teaching of Grade 7 mathematics has the power to facilitate the understanding of different mathematical content areas. Transformation geometry is a challenging topic since it requires visualisation skills in order to master it. Dockendorff and Sola (2017) attest that the major benefit of incorporating technology in mathematics instruction is the competence of visualisation. Teachers spend much time trying to explain this concept with the use of inaccurate drawings. Many learners find it hard to understand when the objects are drawn on the board. Dorji and Ishii (2023) suggest that displaying images, figures, tables and shapes saves time and reduces misconceptions which might be created by manual drawings.

This study found that ICT tools are capable of enhancing the understanding of abstract concepts which aligns with Muhazir and Retnawati (2020) who revealed that ICT in mathematics assists learners in promoting understanding of abstract mathematical concepts. Furthermore, Kiapele (2022) posit that virtual manipulatives bring in concrete resources, which deepens the understanding of abstract knowledge. When teaching concepts such as reflection, translation and rotation, learners are able to clearly view how the objects flip, rotate or slide when using technology. When teaching the topic of patterns, ICT incorporation is able to enhance the understanding of how to extend the patterns since learners engage in online activities where they can create patterns. The pattern's visibility is also enhanced by the use of different colours in shapes that form the pattern. The engagement of learners in online activities implies that learners are actively involved, which also facilitates understanding and knowledge retention. However, Das (2019a) indicated that ICT is not applicable in all mathematics content areas. Overall, this study revealed that one of the benefits of incorporating technology in the teaching of mathematics is facilitating and deepening understanding of difficult concepts.

5.2.1.2 The impact of ICT on learners' concentration and academic improvement

The findings of this study revealed that there are numerous benefits to learners in terms of concentration, interest in mathematics, grasping of concepts and response towards the lesson. During teaching and learning, there is increased concentration compared to when teachers use traditional talk-and-chalk methods. Learners pay full attention, display great interest in the lessons and eagerly participate in the activities done in the classroom. This is corroborated by Meladi and Awolusi (2019), Graham et al. (2020), Kiapene (2022) and Muhazir and Retnawati (2020), who revealed that the incorporation of technology during instruction increases learner interest, focus, concentration, motivation and engagement. Through the integration of ICT, learners create their own knowledge through interacting with other learners and also through accessing online lessons at their own convenience time. Learning opportunities are expanded as learners are able to watch videos on what they did in class to facilitate their understanding, they no longer wait for the teacher to further clarify the concepts that they never understood. Interacting with technology tools allows learners affordances to operate these tools effectively, consequently they can use these tools beyond the teaching and learning environment to deepen the understanding of different mathematics concepts (Dorji & Ishii, 2023). The fact that learners can access the videos on their own, at the own time, shows great independence and great interest in mathematics. Meladi and Awolusi (2019) also maintain that technology provides pedagogical support structures capable of producing independent learners. Moreover, Kiapene (2022) concluded that the use of ICT in the teaching process promotes independence, self-confidence and creativity. Kiapene (2022) believes that the use of visuals to facilitate the understanding of abstract concepts results in the improvement of learners' mathematics grades. In argument Graham et al. (2020); Muhazir and Retnawati (2020) also concluded that the use of ICT in mathematics instructions increases learner performance. Kiru (2018) suggests that ICT pedagogical innovations can result in increased learner achievement in mathematics. Throughout the teaching and learning process, learners are quick to grasp the concepts, resulting in time for teachers to put interventions in place and focus on learners who have difficulties.

It is of concern that some participants were uncertain about the benefits of ICT related to learners' academic performance. Consistent with this finding, Young et al. (2018)

found that the impact of ICT incorporation on learners' mathematic achievement is negligible.

5.2.2 What are the challenges in implementing technology in Grade 7 mathematics classrooms?

This study revealed that there are numerous challenges encountered by teachers when integrating technology in the teaching and learning process. These challenges include lack of training on how to integrate ICT in mathematics, technical challenges and limited knowledge of mathematical software.

5.2.2.1 Lack of training on how to integrate ICT in mathematics

Teachers are not trained to integrate ICT in mathematics, instead they are trained on how to effectively operate the smartboard and their laptops. Teachers are trained on applications such as MS Word and PowerPoint. MS Word is used for administrative work such as preparing lessons, formal and informal activities and recording learners' progress and PowerPoint is often used for presentation of lessons during teaching and learning process. If teachers do not receive appropriate training, it could lead to ineffective ICT integration in mathematics. Studies conducted by Al-Mamary (2022), Kaur (2023), Kiapene (2022), Meladi and Awolusi (2019) and Mir (2019) also highlighted the lack of training as the major constraint in effectively integrating ICT in mathematics. In this study, participants were able to use their ICT knowledge to teach mathematics using YouTube videos and Google forms, thus, integrating ICT in mathematics teaching through autodidactic learning, not because they received training on ICT incorporation specifically in mathematics. Kiru (2018) revealed that mathematics teachers displayed a lower need for ICT skills training in comparison to teachers who teach subjects other than mathematics. The lack of ICT training results in lack of skills, lack of knowledge and awareness of ICT tools that perfectly define ICT integration in mathematics. Kaur (2023) believes that inadequate training results in lack of confidence, and as a result mathematics teachers are reluctant to integrate ICT in mathematics. Al-Mamary (2022) recommended continuous professional development of teachers, allowing effective integration of ICT in mathematics in order to improve pedagogical process.

5.2.2.2 Technical challenges

Teachers also experience technical challenges such as load shedding without any backup systems, malfunctioning of smartboards and laptops, lack of Wi-Fi or connectivity, the distribution of learners' laptops and the process of charging learner's laptops, all of which is time consuming, thus taking time away from teaching. Without proper ICT facilities and infrastructure, the effective adoption and implementation of ICT in mathematics is challenging. Dhital (2018) revealed that the major challenge that inhibits the implementation of ICT in education system is inadequate infrastructure. Furthermore, Dhital (2018) stressed that the importance of the provision of electricity supply in full capacity as the implementation of ICT is dependent on electricity. Previous studies conducted by Ahmed et al. (2019); Al-Mamary (2022); Bayode et al. (2019); Chao (2019); Das (2019a.b) and Singhavi and Basargekar (2019) also outlined the same challenges that were established in this study.

5.2.2.3 Limited knowledge of mathematical software

The findings revealed that teachers have limited knowledge of mathematics software that could aid in the successful integration of ICT in mathematics. Many software packages are available that could enhance the understanding of mathematics including Geogebra. Muhazir and Retnawati (2020) acknowledge that limited awareness of mathematical software result in low levels of implementation. Only two out of seven participants were aware of software like Geogebra, however, they believe that it only has benefits at the high school level. Azizah et al. (2021) concluded that the use of Geogebra increases the visualisation of 2 and 3- dimensional objects which contradicts assumptions that the benefits of Geogebra apply at the high school level. Research has found that Geogebra software also lays a major role in primary school as well.

Teachers in this study used videos, PowerPoint, PDF and games, and believe that they have successfully and effectively integrated ICT in mathematics. This finding aligns with Kiapene (2022) who revealed that most teachers use mathematics software as presentation tools instead of engaging learners in ICT-based hands-on activities which facilitate the understanding of mathematical concepts. A similar conclusion was drawn by Ardiç (2021) who revealed that the majority of participants used presentation applications and PDF reader to teach mathematics instead of

mathematics software. Furthermore, the limited use of mathematical software limits learner's interaction (Ardiç, 2021). According to Muhazir and Retnawati (2020), participants were concerned about their lack of knowledge of mathematics software that caters for any other mathematics topics, other than Geogebra that they can apply in geometry.

5.2.3 How is ICT integrated into Grade 7 mathematics classrooms in the Johannesburg East District?

The findings offer an insight on teacher's knowledge in integrating ICT in mathematics lessons, the development of mathematical skills and how learners react when ICT is integrated during instruction.

5.2.3.1 Teachers' ICT knowledge in integrating ICT in mathematics lessons

Participants voiced their concerns about their limited knowledge on ICT integration in mathematics. The findings revealed that teachers lack knowledge to incorporate ICT in mathematics as well as technology skills. Most participants missed the opportunity to engage learners in activities that evoke quicker thinking skills through ICT. This can be interpreted as that teachers find it challenging to engage learners in mental activities using ICT. In attempting to use ICT to facilitate this activity one participant created room for misconceptions and used an activity that did not fit the level of the learners. The activity displayed inaccuracy, and the teacher kept quiet and never corrected it. In the study conducted by Appavoo (2021), participants wished they had skills to amend readily available digital learning content so that they could ensure that the content fits the level of learners. Dorji and Ishii (2023) suggested that considering the selection of readily available resources, teachers need to do an in-depth analysis to ensure that the content suits the level of learners.

5.2.3.2 The development of mathematical skills

There are different skills that learners need to acquire at the end of each and every content area in mathematics. This study revealed that the incorporation of ICT in mathematics evokes quicker thinking skills that are taught through mental arithmetic. Mental mathematics assists and lays a foundation for procedural knowledge. With the integration of ICT in mental mathematics, activities can be done in one lesson which fully engages learners and prompts quicker thinking as some of the activities are online and timed. The disadvantages being that, there are chances that not all learners would

participate, online activities leave no record that they have been done, hence, learners cannot reflect on where they went wrong.

Participants also used videos in their lessons. The findings revealed that videos play a vital role in developing learners' mathematical understanding and are capable of using visuals that are hard to understand when drawn from the board to clearly explain abstract objects. Appavoo (2021) also believes that the mode of teaching that is enhanced by videos is more beneficial in teaching and learning. Dorji and Ishii (2023) concluded that videos facilitate the modelling of 2- dimensional geometry. Videos are also able to bring sense of real-life situations in the teaching and learning environment, making it even easier for learners to create a relationship between what they learn in the classroom and its application in their daily lives. Muhazir and Retnawati (2020) noted that the use of videos allows learners to explore mathematical ideas, while linking them with nature and real-life situations to facilitate the understanding of mathematics content. Videos are capable of showing steps in procedural knowledge while in comparison, teachers verbally utter those steps, assuming that learners understand what they are saying.

Videos do not only assist in developing learner's skills, but they also assist teachers in bringing knowledge that they were not aware of, or concept building skills that they might have missed out. Oechsler and Borba (2020) attest that the use of videos reveals the new kind and alternative mathematical knowledge. Videos also create valuable extra time as they are able to incorporate concepts that are related, in a single lesson. Videos are not perceived as a teacher's replacement, but rather as an extension of teaching and learning resources. This corresponds with the study conducted by Muir (2018) since the students viewed videos as readily available resources that they can use to revisit the concepts done in class. Teachers are reliant on readily-made videos, Das (2019a) posit that it is due to the lack of knowledge to create mathematical digital content.

5.2.3.3 Learners' reaction to the lessons

The findings revealed that the use of ICT has the affordance to keep learners focused during teaching and learning of mathematics. Abdullahi and Sirajo (2022) believe that learners' attitude towards mathematics becomes positive when ICT is integrated in lessons. Kiapene (2022) also believes that the use of ICT in the classroom keeps

learners focused during learning. High concentration allows learners to pick up the mistakes that their peers make when digital activities are done. These errors are taken as corrections, as well as learning opportunities. According to Ab Jalil et al. (2022), ICT incorporation raises curiosity among learners and they transform from being passive to reactive and eventually to interactive.

When learners are actively involved, they remain engaged, stay alert and fully focused, while creating knowledge in a social setting. Learners become less dependent on the teacher whose role is to facilitate the lesson. The pedagogical process becomes learner-centred instead of learners being passive receivers of knowledge imparted to them by the teacher. Abbad (2021) cautions teachers on the need to encourage interaction and engagement of learners as it creates meaningful learning experience, instead of themselves proving to be experts.

5.2.4 What are the Grade 7 teacher's perspective on the integration of ICT in their mathematics classroom?

The UTAUT model was employed in the study to understand mathematics teacher's perspectives on the integration of technology in Grade 7. This theoretical framework assisted in exploring the drivers that influence teachers in integrating ICT to teach mathematics. The determinants of this theory, performance expectancy, effort expectancy, social influence and facilitating conditions, answer this question of the study.

5.2.4.1 Performance expectancy

The findings indicate that the use of ICT to teach mathematics is perceived as useful since it improves teaching and learning performance. For lesson preparation, teachers are able to prepare lessons through PowerPoint, in which learners are able to see the notes on the smartboards. In this way, teachers' teaching time is improved since they do not spend time writing notes on the board. During lesson delivery, teacher's talking time is also reduced as they are able to open videos that also assist in bringing another voice to explain the concept being taught. The findings also revealed that the use of ICT improves teachers' practices because technology allows for a variety of resources to be used during teaching and learning process. Digital resources are readily available online, therefore, there is no need for teachers to create them; however, teachers need to do thorough planning to ensure that appropriate resources are used.

The process of teaching and learning is also improved because learners' interest and curiosity in mathematics is aroused. Learners' concentration and engagement are also increased. Pertaining to this study, performance expectancy influences teachers' behavioural intention to use technology in mathematics. Studies conducted by Graham et al. (2020) and Alshammari (2021) align with this study as they indicated that there is a positive impact of performance expectancy on behavioural intension to use ICT as the participants acknowledged that it improves teaching performance. Ab Jalil et al. (2022) contradict the result of this study since their findings proved that performance expectancy has no effect on teachers' behavioural intention to use ICT.

5.2.4.2 Effort expectancy

Participants of this study perceived the use of ICT as relatively easy to use, however, they admitted that it requires proper planning and preparation, careful selection of resources that are relevant and appropriate. If the lesson includes videos, the teacher needs to ensure that the video is appropriate and the content must meet the level of the learners. This study does not view planning as a problem because even if a teacher is using conventional methods of teaching, a thorough planning and preparation is required. Teachers in this study used technology during their lessons, operating smartboards and laptops and were also able to access online material with ease. Teachers also used videos effectively in their lessons.

With limited ICT knowledge and training, the findings revealed that participants believe that using technology in mathematics is not complex. Therefore, it can be concluded that effort expectancy plays a significant role on behavioural intention to integrate ICT in mathematics. The findings of Alshammari (2021) illustrate that effort expectancy is a significant determinant on teachers' use of ICT in the classroom. However, Graham et al. (2020) opined that teachers are not using ICT because they find it easy to use, but it could be the fact that it simply improves their job performance, therefore, effort expectancy does not necessarily predict the behavioural intention to incorporate ICT.

5.2.4.3 Social influence

The findings of this study indicated that people surrounding the participants play a significant and positive role in influencing them in the integration of ICT to teach mathematics. School managers support and encourage them to use ICT and ensure that all the teachers who use ICT are not challenged in its use. According to Kiru

(2018), leaders and school management have a major impact on the overall adoption of ICT in schools as they are capable of ensuring that there is provision of infrastructure, teachers receive continuous professional development and the challenges are attended to. Colleagues too, play a vital role in encouraging teachers to use ICT in mathematics. All teachers at the school use ICT tools in different learning areas. When they encounter challenges, they assist each other and, in this way, encourage one another to incorporate ICT during teaching and learning. According to Kiru (2018) teachers working together results in learning from one another, while leading to frequent use of ICT in the classroom. The findings of this study also revealed that the use of ICT in schools has become the norm and part of school culture as there is a shared vision of ICT integration. This aligns with the study conducted by Venkatesh (2003) since the findings revealed that social influence has a positive effect on behavioural intention to integrate ICT in mathematics.

5.2.4.4 Facilitating conditions

Without well-established ICT infrastructure, it is challenging to integrate ICT in teaching and learning. Dorji and Ishii (2023) regards availability of ICT tools as an enabling condition for effective and successful incorporation of technology. Grade 7 teachers were equipped with ICT facilities in their schools which is an indication that teachers use ICT tools because they are available. However, the availability of ICT tools has no significant effect on teachers' intention to use ICT tools. Graham et al. (2020) opined that teachers' behavioural intention to use ICT is not influenced by the facilitating conditions, but it could be the fact that technology is becoming mandatory and available in schools as a coping mechanism in the 4IR era.

The findings also revealed that technology devices are only available in Grade 7 classrooms in most primary schools in the Johannesburg East district. This raises concerns for teachers who teach other grades and implies that, teachers who do not teach Grade 7 have no access to laptops and they have no knowledge of how ICT gadgets work. Das (2019a) indicates the importance of accessibility of ICT tools to effectively integrate ICT tools in mathematics teaching and learning. Lack of technology has a negative impact on teachers, as well as on learners. All learners should be exposed to the integration of ICT in the teaching and learning process. Viberg et al. (2020) confirmed that learners are not digitally competent as they are

expected to be which has a negative impact as teachers end up denying learners the opportunity to use their laptops. The study concludes that facilitating conditions have no significant impact on teachers' behavioural intention to use ICT in mathematics.

5.3 CONCLUSIONS

Firstly, the benefits of integrating ICT in this study involves facilitation of understanding of mathematics subject content. The integration of ICT in transformation geometry and patterns plays a vital role during teaching and learning. The understanding of these concepts is facilitated by the use of virtual manipulatives. With ICT use, learners can clearly view objects rather than when they are drawn on the board, while also avoiding misconceptions. Learners are engaged in hands-on activities of manipulating these objects enhancing the understanding of these concepts. Learners become independent, engage more in the lessons, concentrate fully and they are more active. The study has no clear indication on the improvement on the learner's achievement in mathematics as all teachers were uncertain about the effect of technology on learners' grades.

Secondly, there are many barriers that were revealed in this study which include lack of adequate knowledge to integrate ICT in mathematics pedagogy, technical challenges such as lack of back-up systems for electricity power, malfunctioning of laptops and smartboards. Teachers also lack the knowledge of mathematics software to integrate in lessons. Teachers use their limited ICT knowledge to integrate ICT in their practice. For instance, the use of Google forms and YouTube to access mathematics teaching and learning videos. This indicates that teachers are aware of the benefits of integrating technology to teach mathematics, but they are limited by inadequate training. This is a major constraint because it limits teachers from accessing proper knowledge about how to effectively incorporate ICT in mathematics.

Thirdly, the observation of mathematics lessons based on ICT tools gave an insight into how teachers integrate ICT in mathematics. Participants lacked skills of how to integrate ICT to teach certain concepts or subject content. They use readily available resources that do not suit the level of the learners and lack skills to alter those activities to ensure they are appropriate. The use of ICT promotes a learner-centred approach. However, the disadvantages being there is no evidence to trace the work done and

also that there is a probability that not all learners participate in the activity. This study also revealed the power of videos in developing mathematical concepts. Videos give detailed information on concepts and clear images, they bring real-life situations into the classroom, providing alternative ways on procedural knowledge building. The use of ICT is also commended as it has shown increased level of interest and concentration, curiosity to participate in activities and a positive response to the lessons.

Lastly, according to the determinants of the theory that were used to explore teacher's perspectives, teachers have accepted the use of technology to teach mathematics due to the fact that it makes their jobs to be relatively easy and they can see the difference in learners' attainment of the learning outcomes. They perceived the system of technology not as a complex system since no effort is required to operate it. Social influence has proved to be a major indicator of behavioural intention to use ICT to teach mathematics since school management has shown great support and colleagues have an influence on the use of technology The availability of ICT facilities also played a significant role in motivating and encouraging teachers to use ICT in the classroom. The findings of this study align with the initial foundations of the UTAUT theory which underpin this study.

In closure, ICT integration has many benefits in enhancing the understanding of different concepts in mathematics. Mathematics teachers need to work together and find ways to empower, motivate and encourage each other, in order to effectively incorporate ICT in mathematics.

5.4 RECOMMENDATIONS

Following are the recommendations of this study. These recommendations give an insight on what can be done to improve the integration of ICT in teaching and learning of mathematics:

- Pertaining to this study, three out of four schools apply ICT only in grade seven. The government needs to ensure that there is enough funding to equip the schools with necessary ICT facilities from the lowest grades as Grade R to Grade 7. This will reduce the challenges related to teachers spending more time trying to assist learners to navigate through different sites.

- Teachers lack knowledge and skills to integrate ICT tools to teach mathematics. The GDE needs to reinforce the development of teachers by providing continuous training that will equip mathematics teachers with adequate skills necessary to effectively integrate ICT in mathematics.
- Curriculum planners and designers need to fully include the integration of ICT in the curriculum, with clear guidelines on how to integrate it per learning area, in this case, teachers will be motivated to use ICT.
- The Departmental Heads need to promote the formation of Professional Learning Communities (PLCs) that will enhance collaboration among teachers across ICT schools in the district, while enhancing best practices of ICT integration in mathematics. This would include sharing information on how they integrate ICT tools in mathematics lessons, which software are available, how to integrate them and how to promote learner's academic performance.
- The government must ensure that back up system for power supply is installed in schools to ensure that ICT integration runs smoothly.

5.5 SUGGESTIONS FOR FUTURE RESEARCH

This study investigated the effects of ICT integration to teach mathematics in grade 7, in a broader sense. Future research can focus on the awareness of mathematical software such as Geogebra especially to primary school teachers since the participants of this study argued that they are not aware of mathematical software, those who are aware of it concluded that it is suitable for secondary schools only.

The study revealed that teachers are not certain about the improvement of academic performance through ICT integration, thorough research is recommended to investigate the impact of ICT integration in learner's academic performance in mathematics.

The study also recommends the articulation of learner positive reaction due to ICT integration as a way of motivating teachers to refrain from using conventional methods of teaching and learning.

Future studies could also focus on ICT integration to explore the challenges that are specific to mathematics content.

5.5 DELIMITATIONS AND LIMITATIONS OF THE STUDY

The study was limited to only four schools in the Johannesburg east district in Gauteng. The nature of this study, was restricted to qualitative research. The study aimed at yielding in-depth data to fully understand the phenomena at hand. It is therefore impossible to generalise the results of the study since the sample size is very small.

The study sampled eight Grade 7 mathematics teachers, but one of the teachers had an injury and did not participate in the study. In one of the schools, there was no connectivity which had been an ongoing problem and teachers were limited to using only the digital content provided by the GDE. Two participants also had challenges and as a result, did not participate in the focus group interview. However, on a positive note, the data was sufficient to understand the integration of ICT in Grade 7 mathematics teaching and learning.

5.7 A FINAL WORD

Mathematics has always been labelled as a challenging learning area which is displayed by poor performance. In mathematics teaching and learning, teachers still use outdated traditional methods caused by the lack of knowledge to integrate ICT in mathematics as a subject. The findings of this study indicate the necessity to prioritise the provision of continuous ICT training that is specific to mathematics teaching and learning. The provision of training will ensure that ICT is integrated effectively which should have a significant and positive result on learner achievement.

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APPENDICES

Appendix A: Ethical Clearance Certificate

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2024/03/13

Ref: **2024/03/13/57858357/06/AM**
Name: Ms VV Ntshingila
Student No.:57858357

Dear Ms VV Ntshingila

Decision: Ethics Approval from 2024/03/13 to 2027/03/13

Researcher(s): Name: Ms VV Ntshingila
E-mail address: 57858357@mylife.unisa.ac.za
Telephone: 0735643436

Supervisor(s): Name: Prof S Meeran
E-mail address: meeras@unisa.ac.za
Telephone: 0124296039

Title of research:

Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.

Qualification: MEd Curriculum studies

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2024/03/13 to 2027/03/13.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2024/03/13 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

Open Rubric

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2027/03/13**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2024/03/13/57858357/06/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof Mpine Makoe
EXECUTIVE DEAN
qakisme@unisa.ac.za

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Appendix B: Permission Letter from the District

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	19 February 2024
Validity of Research Approval:	08 February 2024– 30 September 2024 2024/629
Name of Researcher:	Ntshingila VV
Address of Researcher:	80 Klipspringer Avenue
	Leondale
Telephone Number:	0735643436
Email address:	vvntshingila@gmail.com
Research Topic:	Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.
Name of University:	UNISA
Type of qualification	Masters
Number and type of schools:	4 Primary Schools
District/s/HO	Johannesburg East

Re: Approval in Respect of Request to Conduct Research

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

19/02/2024

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

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

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....

Dr. Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: ....19/02/2024.....

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

Appendix C: Request Letter to Conduct the Study from Principals

Information sheet to the principal

Request for permission to conduct research at _____ primary school

Title: Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.
Date: _____

Name of the person to who you address the request: _____
Department of the person: _____
Contact details: _____
Email: _____

Dear Principal

I, Vuyiswa Ntshingila, am doing research under supervision of Prof Meeran, a supervisor in the department of Curriculum and Instructional studies towards Masters of Education at the University of South Africa. We are inviting you to participate in a study entitled: Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.

The aim of the study is to investigate the experiences of grade 7 mathematics teachers in the Johannesburg East District in integrating ICT.

Your school has been selected because it is one of the primary schools that is in possession of ICT tools in the Johannesburg East district.

The study will entail classroom observation during teaching and learning of mathematics using the ICT tools. Teachers will also be interviewed on their experiences on integrating ICT while teaching mathematics. Focus group interview will also be conducted, whereby a common venue will be used for the teachers from the four selected schools, including your school.

The benefits of this study include acquiring knowledge about how ICT is integrated in mathematics classroom, through the experiences of other teachers. Teachers who are experiencing challenges when integrating ICT will also get recommendations on they can overcome these challenges.

There are no potential risks that are involved in the study.

There will be no reimbursement or any incentives for participation in the research.

Feedback procedure will entail providing participants with the transcribed data so that they can confirm the original responses they provided. Participants will be given the researchers contact details should they wish to know about the findings of the research. My supervisor Prof Meeran can be contacted on 0124296039 for any information pertaining the study. Alternatively, her email address is meeras@unisa.ac.za.

Yours sincerely

Vuyiswa Ntshingila

The researcher

0735643436

Appendix D: Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Date: 8 January 2024

Title: Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.

Dear prospective participant: Grade 7 Mathematics teachers

My name is Vuyiswa Ntshingila. I am doing research under supervision of Prof Safura Meeran, a professor in the Department of Curriculum and Instructional studies towards Master's degree in education at the University of South Africa. We are inviting you to participate in a study entitled Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District. My supervisor Prof Meeran can be reached on 0124296039 or meeras@unisa.ac.za if there are any questions regarding the research.

WHAT IS THE PURPOSE OF THE STUDY?

Mathematics is incredibly significant in people's daily life since it helps with decision making, problem solving, and critical thinking (CAPS, 2011). The identified issues are learners' poor math performance and the usage of obsolete math teaching methodologies. Teachers are constantly looking for improved tactics to help students improve their arithmetic ability. Mathematics is a difficult subject that many students fear because they incorrectly believe it assesses one's intellectual capacity. With technology's rising significance in knowledge acquisition, this study is vital because the results will provide insight into the consequences of incorporating ICT in grade 7 mathematics classrooms.

WHY AM I BEING INVITED TO PARTICIPATE?

You are invited to participate in the study because you are an important mathematics educator. You have been recommended by one of your colleagues who believes that you will be able to provide relevant information that will be beneficial to the study since you are committed to your work. You are also invited because you have experience before and after the implementation of ICT in your

school. I obtained your contact details from a colleague who recommended you as the suitable person who can provide relevant information for this study.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

For the purpose of gathering information, classroom observations will be conducted, whereby the participant will be observed on how they integrate ICT in mathematics teaching and learning. The second step will be recorded semi-structured interviews with individual teachers on their experiences on ICT integration. Lastly, focus group interview will be conducted where all participants will gather in a group and discuss the phenomena at hand. During interviews, all questions will be related to teaching mathematics, a tape recorder will be used to avoid missing any important information. Questions will be the same for all the participants, but since it is semi-structured interviews, it will allow probing. Observations will take place during school hours, and due to the allocation of time for mathematics period, only 60 minutes will be used. Approximately 60 minutes will be used to complete individual interviews and focus group interviews. Focus group interview will be done after the normal school hours.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

Your participation in the study will contribute in providing knowledge which will assist other teachers on how they can improve on ICT integration in mathematics classroom. Teachers will see the value of enhancing the utility of technology in the classroom, as it expands the learning resources in the classroom. The study will also help on how to deal with challenges that teachers encounter. Overall, the study will shed light on how ICT can be implemented effectively, hence providing curriculum designers with key constructs that they focus on when planning mathematics curriculum.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The study holds no possible risks. There is no physical harm that will be caused since only observation and interviews will be conducted in this study as a way of collecting data. The only identified inconvenience is that the study requires your time. This information sheet and the consent form

provides all the information on the nature of the study regarding the confidentiality of the participants. The identity of participants will be kept confidential.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team as well as the other participants in the group, will know about your involvement in this research. Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

The information that you provide will remain, anonymous, however, it will be used for journal articles and conference proceedings. Journals and conference proceedings will be submitted for publication, but individual participants will not be identifiable in them. Please keep in mind that it is sometimes impossible to make an absolute guarantee of confidentiality or anonymity, e.g. when focus groups are used as a data collection method.

A focus group is a form of data collection where the participants form a group to discuss the matter that is being investigated. While every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason, I advise you not to disclose personally sensitive information in the focus group.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Hard copies will be shredded and/or electronic

copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme, if it is necessary to destroy the information.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

Participation on the study is voluntary, there are no payments or any incentives that will be received for participating in the research.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

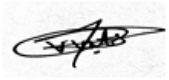
This study has received written approval from the Research Ethics Review Committee of the College of Education, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact me on 0735643436 or email me on vvntshingila@gmail.com. My supervisor Prof Meeran can also be contacted on 0124296039 or email: meeras@unisa.ac.za. The findings are accessible for the period of five years.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.



Vuyiswa Nsthingila

Appendix E: Participant Consent Letter

UNISA | college of education

CONSENT/ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the _____

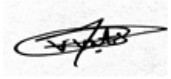
I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) _____

_____ _____

Participant Signature Date

Researcher's Name & Surname (please print): Vuyiswa Vellierrie Ntshingila



Researcher's signature Date

Appendix F: Parental Consent Form

PARENTAL CONSENT FOR MINORS TO PARTICIPATE IN A RESEARCH PROJECT

Dear Parent

Your child is invited to participate in a study entitled: Exploring the effects of integrating ICT to teach grade 7 mathematics in the Johannesburg East District.

I am undertaking this study as part of my master's research at the University of South Africa. The purpose of the study is to explore the integration of Information and Communication Technologies (ICT) in mathematics teaching and learning and the possible benefits of the study are the improvement of teaching and learning strategies during mathematics instruction. I am asking permission to include your child in this study because your child is doing grade 7 and that is the grade in which the study is based. I expect to have thirty other children from his/her class participating in the study.

If you allow your child to participate, I shall request him/her to:

- Be at school on the day of the classroom observation.

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His/her responses will not be linked to his/her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are that the results of the study will give an insight on the effect of integrating ICT in mathematics classroom. The positive impact will assist the department of education to prioritise ICT in mathematics curriculum, while the negative impact will also assist the department on how they can improve so that ICT can be used effectively and benefit our learners. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect

him/her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will be available. During class observation period, your will be placed in the other grade 7 classroom which will not be taking part in the study.

In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

The benefits of this study involve acquiring knowledge about how ICT is integrated when teaching mathematics, with an aim of improving teaching and learning strategies in mathematics since it is perceived as a troubling and difficult subject. There are no potential risks involved in the study. There will be no reimbursement or any incentives for participation in the research.

If you have questions about this study please ask me or my study supervisor, Prof Meeran, Department of Curriculum Studies, College of Education, University of South Africa. My contact number is 0735643436 and my e-mail is vvntshingila@gmail.com. The e-mail of my supervisor is meeras@unisa.ac.za. Permission for the study has already been given by the principal and the Ethics Committee of the College of Education, UNISA.

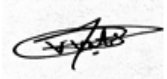
You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Name of the child: _____

Parent/guardian's name (please print): _____

Parent/guardian's signature: _____

Date: _____



VUYISWA NTSHINGILA _____

Researcher's name(print) Researcher's signature Date

Appendix G: Learners' Assent Form

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Learners assent letter

A LETTER REQUESTING ASSENT FROM LEARNERS IN A PRIMARY SCHOOL TO PARTICIPATE IN A RESEARCH PROJECT

Dear learner, Date_____

My name is Teacher Ntshingila and would like to ask you if I can come and watch you doing mathematics with your teacher. I am trying to learn more about how children do mathematics with the help of technology in the classroom.

If you say YES to do this, I will come and watch you when you are with your teacher doing mathematics. I will not ask you to do anything that may hurt you or that you don't want to do.

I will also ask your parents if you can take part. If you do not want to take part, it will also be fine with me. Remember, you can say yes or you can say no and no one will be upset if you don't want to take part or even if you change your mind later and want to stop. You can ask any questions that you have now. If you have a question later that you didn't think of now, ask me next time I visit your school.

Please speak to mommy or daddy about taking part before you sign this letter. Signing your name at the bottom means that you agree to be in this study. A copy of this letter will be given to your parents.

Regards

Teacher V.V Ntshingila

Your Name	**Yes, I will take part** 	**No, I don't want to take part** 
Name of the researcher	**Vuyiswa Ntshingila**	
Date		
Witness		

Appendix H: Observation Tool

Observation schedule

- ICT tools that are utilised in grade 7 to teach mathematics.
- How these tools are being integrated.
- Observing the actual mathematics content being used and how it is used using ICT.
- Learners response towards the lesson.
- Observed benefits during teaching and learning.
- Challenges that teachers encounter during the lesson.
- Contextual factors.

Appendix I: Semi-Structured Interview Guide

Semi-structured interview questions

- How long have you been teaching mathematics?
- When was the ICT tools implemented in the school?
- Did you receive training on the ICT integration in mathematics pedagogy? Explain.
- How would you describe the change that has been brought by ICT integration during teaching and learning?
- Which content areas in mathematics work well with ICT tools?
- How do you incorporatethese tools in that content area?
- Have you seen any improvement in mathematics performance using the ICT tool? Explain.
- What are the benefits to using technology to teach matematics?
- What are the challenges that you encounter when using technology to teach mathematics?
- How do you overcome these challenges?
- What type of support do you get from when incorporating ICT tools in the classroom? Describe.

Appendix J: Focus Group Question Tool

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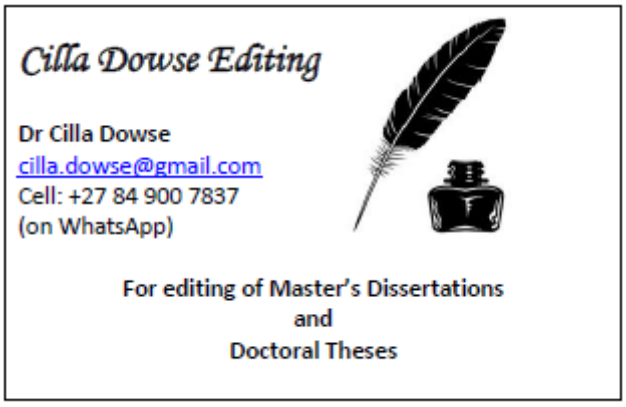
Focus group interview questions

- To what extent would you say ICT integration enhances mathematics teaching and learning?
- What is the impact of ICT integration in learner's performance?
- Provide us with success stories of using ICT in your classroom.
- Would you perceive the use of ICT as relatively easy to use? Explain.
- How would you encourage other mathematics teachers to incorporate ICT tools in their classroom?
- How do your colleagues and the school principal perceive the use of ICT in mathematics classroom?
- To what extent do ICT facilities in your school influence you to integrate ICT in mathematics?
- What do you think can be done to sustain the use of ICT in mathematics classroom?
- Any recommendations on how educators can effectively integrate ICT, especially in grade 7?
- Have you heard of the concept, 'Community of Practice'? How can you work together to ensure that mathematics teaching and learning is effectively using ICT tools?

Appendix K: Proof of editing



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VUYISWA VELLIERRIE NTSHINGILA

MASTERS IN EDUCATION

CURRICULUM AND INSTRUCTIONAL STUDIES

UNIVERSITY OF SOUTH AFRICA

EXPLORING THE EFFECTS OF INTEGRATING ICT TO TEACH GRADE 7 MATHEMATICS IN THE JOHANNESBURG EAST DISTRICT

Cilla Dowse
16 September 2024

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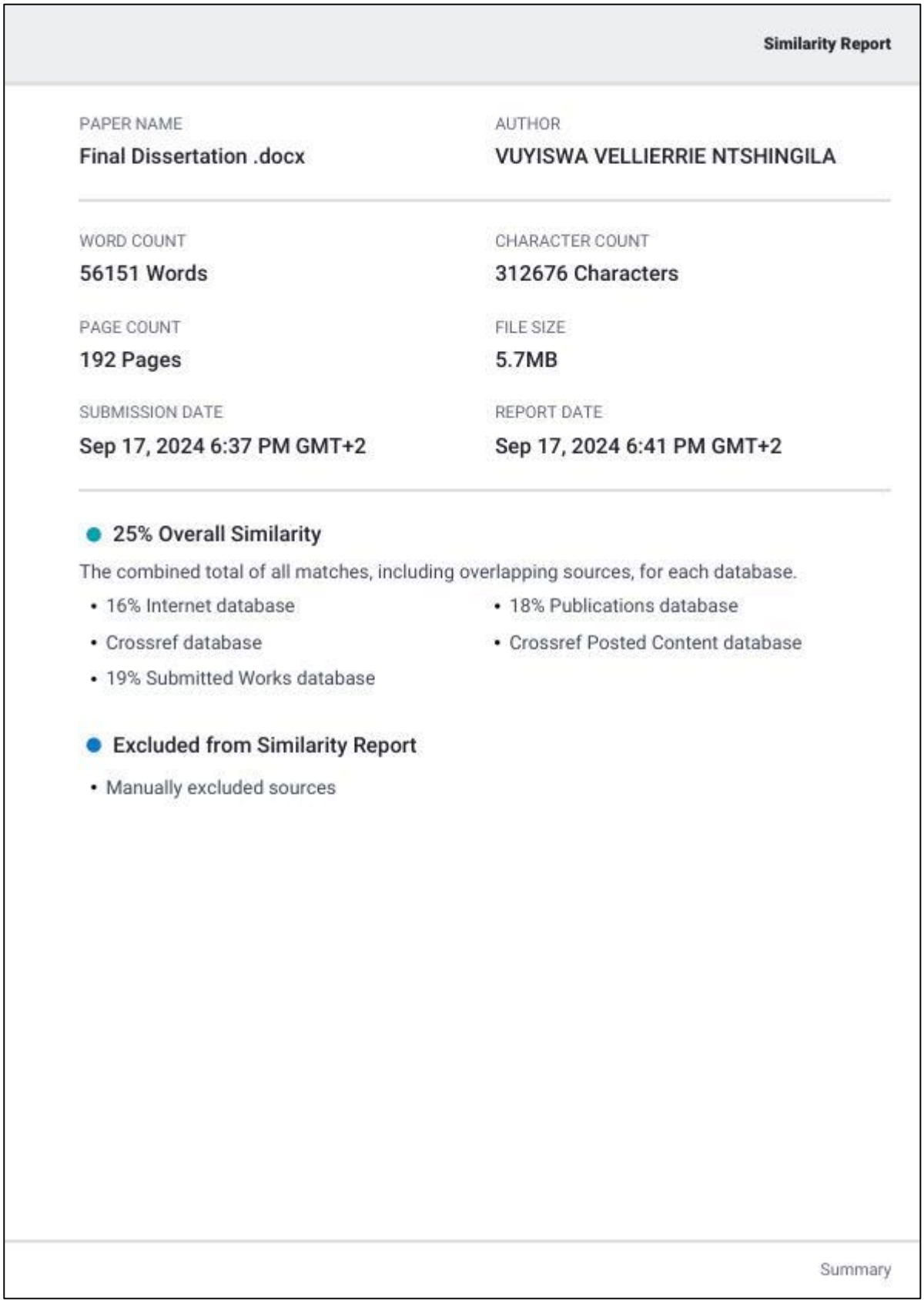
Appendix I: Turnitin Report



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