# Exploring the integration of technology - based tools in Intermediate Mathematics classrooms

By

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A Dissertation submitted to the School of Education, University of KwaZulu-Natal, in partial fulfilment of the requirements for the degree of Master of Education (Curriculum Studies).

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# DECLARATION

I, Thobekile Mlilo, declare that the research reported in this dissertation is my original work submitted in partial fulfilment of the requirements for the degree of Master of Education (Curriculum Studies).

This dissertation has not been submitted for any degree or examination at any other tertiary institution or university.

Where use has been made of the work of other people, such work has been duly acknowledged in the text and referenced.

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# DEDICATION

This dissertation is dedicated to all teachers, working tirelessly to improve teaching and learning of mathematics in primary schools.

# ACKNOWLEDGEMENTS

Glory is given to God for empowering me with strength throughout the course of the study.

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# ABSTRACT

There is evidence that technology use in South Africa is increasing, furthermore its implementation supports teaching and learning of mathematics. However, teacher competence, lack of resources and other challenges limit the effective integration of technology-based tools in some schools.

Due to underperformance of learners in mathematics, innovative teaching methods have been considered and introduced into mathematics classrooms. One of the innovative ways used in the schools is the integration of technology-based tools. The introduction of technology-based tools in mathematics classrooms has changed teaching and learning in various ways. These tools have changed how teachers prepare and deliver lessons and in the same way, changed how learners make sense of mathematical concepts. Research shows that technology-based tools have the potential to enhance teaching and learning of mathematics from primary schools through high schools.

The purpose of this study was to explore integration of technology-based tools into Intermediate Phase mathematics classrooms. The study was carried out in one of the primary schools in Durban, KwaZulu-Natal in South Africa. A qualitative approach was adopted and informed by the interpretive paradigm. The data collection methods used included observation, questionnaires and interviews. Eight participants (teachers) took part in the study. The analysis of the data revealed that integration of technology-based tools in mathematics classrooms assists a learner to grasp mathematical concepts with ease, makes learning fun and can better the performance of learners in mathematics. Effective learning of mathematics takes place in relaxed environments where learner-centred teaching methods are employed.

## ABBREVIATION AND ACRONYMNS

| Abbreviation/Acronym | Description |
|---|---|
| ANA | Annual National Assessments |
| CAPS | Curriculum Assessment Policy Statement |
| DBE | Department of Basic Education |
| DoE | Department of Education |
| ICT | Information and Communication Technologies |
| GET | General and Education Training bands |
| PCK | Pedagogical Content Knowledge |
| SACMEQ | Southern Africa Consortium for Monitoring Quality Education |
| TCK | Technological Content Knowledge |
| TIMMS | Trends in International Mathematics and Science Study |
| TPK | Technological Pedagogical Knowledge |
| TPACK | Technological Pedagogical Content Knowledge |

# LIST OF TABLES AND FIGURES


| Table Number | Page Number | |
|---|---|---|
| Table 1 | 3 | ANA results for Grade 4 – 6 (2013/ 2014) |
| Table 2 | 41 | Mathematics Content Area in the Intermediate Phase |
| Table 3 | 52 | The five stage development by Niess et al. |
| Table 4 | 61 | The summary of participants |

| Figure Number | | |
|---|---|---|
| Figure 1 | 38 | The TPACK Framework by Mishra & Koehler |
| Figure 2 | 78 | An iPad used by one of the learners at the participating school. |
| Figure 3 | 79 | A projector and the whiteboard used at the participating school |
| Figure 4 | 80 | NumberSense workbooks projected on the whiteboard |
| Figure 5. | 85 | Different containers showing volume (use of colourful liquids) |
| Figure 6 | 86 | Visual learners are able to see colourful 3Dshapes |
| Figure 7 | 88 | Grade Six learners watching Youtube video (Maths Antics) at the participating school |
| Figure 8 | 94 | Learners collaborate on researching about 3D shapes on the internet |
| Figure 9 | 97 | A mathematics game played by a group of learners after completion of written work |

# Table of Contents

Declaration ..... ii
Dedication ..... iii
Acknowledgements ..... iii
Abstract ..... iv
Acronyms and abbreviations ..... v
List of tables ..... vi
List of figures ..... vi
Contents Page ..... vii

**CHAPTER 1: BACKGROUND AND INTRODUCTION**

1.1 Introduction ..... 1
1.2 Background of the study ..... 2
1.3 General Performance of learners in Mathematics ..... 4
1.3.1 Trends in International Studies ..... 4
1.3.2 Southern Eastern Africa Consortium for Monitoring Education Quality ..... 5
1.3.3 Annual National Assessment ..... 5
1.4 Policy on ICT ..... 6
1.5 Focus of the study ..... 7
1.6 Significance of the study ..... 8
1.7 Rationale of the study ..... 9
1.8 Research Objectives ..... 9
1.9 Research Questions ..... 9
1.10 Explanation of key words ..... 10
1.11 Organisation of the study ..... 12
1.12 Conclusion ..... 13

**CHAPTER 2: REVIEW OF LITERATURE**

2.1 Introduction ..... 15
2.2 Learning Theories and Technology Integration ..... 16
2.3 Technology Integration ..... 17
2.4 Technology in Mathematics classrooms ..... 20
2.5. Factors influencing integration of technology in Mathematics classrooms ..... 21
2.5.1 Limited access to ICT ..... 21
2.5.2 Rural VS Urban schools ..... 25
2.5.3 Rigid teaching methods ..... 25
2.5.4 Lack of Teachers' Technological Knowledge and Content Knowledge ..... 28
2.5.5 Lack of Technological Knowledge in the management personnel ..... 29

2.5.6 Teachers' attitudes and lack of confidence ..... 30
2.6 Benefits of integrating technology into mathematics teaching ..... 32
2.7 Conclusion ..... 33

## CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Introduction ..... 35
3.2 What is Technological, Pedagogical & Content Knowledge ..... 36
3.3 Exploring Technological, Pedagogical & Content Knowledge Framework ..... 38
3.3.1 Introduction ..... 38
3.3.2 Exploring Content Knowledge ..... 38
3.3.3 Exploring teachers' Pedagogical Knowledge ..... 41
3.3.4 Exploring Technological Knowledge ..... 41
3.3.5 Exploring teachers' Pedagogical Content Knowledge ..... 42
3.3.6 Exploring teachers' Technological Content Knowledge ..... 43
3.3.7 Exploring teachers' Technological Pedagogical Knowledge ..... 44
3.3.8 Exploring Teachers' Technological, Pedagogical & Content Knowledge ..... 46
3.4 Exploring the relationship between TPACK & Constructivism ..... 46
3.5 Exploring the relationship between TPACK & Mathematics education ..... 48
3.6 Exploring the TPACK Model & the Developmental Model ..... 48
3.7 Developing teachers' competencies in using TPACK in classrooms ..... 49
3.8 Critics of the TPACK framework ..... 50
3.9 The Development process of integrating technologies into mathematics ..... 50
3.10 Conclusion ..... 54

## CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction ..... 55
4.2 Research Questions ..... 55
4.3 Research Paradigm ..... 55
4.4 Research Design and Methodology ..... 57
4.5 Sampling ..... 58
4.5.1 Purposive Sampling ..... 58
4.5.2 Study Setting ..... 59
4.5.3 Description of participants ..... 60
4.5.4 Description of technology –based tools used in the participating school ..... 63
4.6 Data Collection Techniques ..... 64
4.7 Pilot Study ..... 65
4.8 Observation ..... 66

4.9 Questionnaires ..... 67
4.10 Interviews ..... 69
4.11 Ethics ..... 70
4.12 Informed Consent ..... 70
4.13 Confidentiality ..... 71
4.14 Reliability and Validity ..... 72
4.15 Limitations ..... 72
4.16 Conclusion ..... 74

## CHAPTER 5: DATA PRESENTATION

5.1 Introduction ..... 75
5.2 Technology – based tools in Mathematics ..... 76
5.3 Exploring Student Engagement ..... 81
5.4 Exploring visualisation ..... 83
5.5 Catering for diverse learners ..... 86
5.6 Integration of technology-based tools ..... 89
5.7 Collaboration ..... 92
5.8 Positive Student Behaviour ..... 94
5.9 Learning mathematics through games via a technology based tool ..... 96
5.10 Effective teachers ..... 97
5.11 Conclusion ..... 99

## CHAPTER 6: FINDINGS AND CONCLUSIONS

6.1 Introduction ..... 100
6.2 Summary of findings ..... 100
6.2.1 Which technology-based tools are integrated into mathematics classrooms? ..... 101
6.2.2 How are technology – based tools integrated into mathematics classrooms ? ..... 104
6.2.3 Why are technology based tools integrated into mathematics classrooms? ..... 106
6.3 How is the current study beneficial to mathematics education ..... 108
6.4 Recommendations ..... 109
6.5 Limitations ..... 111
6.6 Conclusion ..... 111

References ..... 113
Appendices ..... 121

# Chapter One

## 1.1 Introduction

The integration of technology - based tools in the education system, has become very popular in the 21st century. van Niekerk and Blignaut (2014) believe that it is essential for classroom practitioners to include various technologies in teaching and learning environments, to keep up with the current demands of education. Learning also, has a new meaning as it is strongly influenced by these digital information sources however, Ramorola (2013) states that inadequate planning and lack of resources may deter effective integration of technology - based tools into lessons. There is also a need for competent leaders in the education system to motivate teachers to make use of these tools in a way that will be beneficial to the learner. The use of technology - based tools has influenced a radical change in the learning environment in the sense that, there is a shift from teacher-centred approaches to learner-centred approaches (Dilworth, Donaldson, George, Knezek, Starkweather & Robinson, 2012). According to the views of social constructivists each learner is an active participant of his/her learning and this promotes the use of innovative teaching methods which are learner centred enabling lifelong learning and independent problem-solving (Soobik, 2014). Teacher-centred approaches on the other hand, focus more on the teacher than the learner. Nouzha El (2013) believes that Information and Communication Technologies (ICT) pedagogical innovations were constructed in order to move away from a teacher-centred approach to one that is more learner-centred.

Kafuylilo (2014) believes that teachers need to be conversant with new educational reforms and innovations. Such reforms usually come with new instructional practices and behaviours. Considering poor mathematics performance experienced by learners in South African schools, the use of technology - based tools has the potential to help learners in constructing knowledge and creating meaning out of abstract concepts in mathematics. He further mentions that the rapid change brought by emergent technologies offer opportunities to understand mathematical concepts in constructive and purposeful ways. Technology - based tools are also believed to facilitate construction of mathematical knowledge and conceptual understanding for learners with different learning needs (Adanides & Nicolau, 2004). The researcher believes that these tools can benefit learners with diverse needs in today's mathematics classrooms. Wachira and Keengwe (2011) suggest that teachers must strive to use technology - based tools on a consistent basis as this is an effective means of

supporting students' understanding of mathematics content. Stols, Fereira, Pelser, Olivier, van Der & Venter (2015) pointed that a critical challenge faced by South Africa and many other countries with emerging economies is mathematics teachers' lack of content and pedagogical knowledge. For these tools to be used effectively the Department of Education needs to put teacher training programs in place. Appropriate integration of technology - based tools sustains the learners' attention and promotes meaningful teaching and learning in the classroom (Bester & Brand 2013).

## 1.2 Background of the study

A study conducted by Southern and Eastern Africa Consortium for Monitoring Educational Quality (SAQMEQ) in 2011 and Trends in International Mathematics and Science Studies (TIMMS) in 2015 revealed and confirmed that South African learners performed poorly in mathematics. TIMMS mathematics items are designed to measure learner knowledge in different concepts. TIMMS report in 2017 showed that among middle income countries that participated, South African learners had the lowest performance. Local standardised assessments, Annual National Assessments (ANA) which commenced in 2013 also revealed the same dilemma. These assessments were initiated to assist learners to grasp mathematical concepts and achieve better results in mathematics. According to the 2015 ANA report learners in the Intermediate Phase had the following results;

***Table 1***

**ANA RESULTS FOR 2012, 2013 AND 2014 IN THE INTERMEDIATE PHASE**

| Grade | 2012 | 2013 | 2014 |
|---|---|---|---|
| 4 | 37% | 39,2 % | 37% |
| 5 | 30% | 35% | 37% |
| 6 | 27% | 41,2 % | 43,8% |

***Source: Department of Education, (2015 p. 154)***

These results clearly indicate underperformance in mathematics for the years 2012, 2013 and 2014. Learners in the Intermediate Phase performed below fifty per cent in three consecutive years which indicates the need for urgent intervention as a country.

South Africa has experienced transformation and new developments in the education system in recent years. The inclusion of technology into teaching and learning environments has become a priority in the South African education system (Laher & Hart, 2015). The inclusion of technology in the classroom fulfils the set outcomes and aims laid in the Mathematics Curriculum Assessment Policy Standards (CAPS). Leendertz, Blignaut, Nieuwoudt, Els, and Ellis (2013) pointed out that mathematics curriculum outcomes can be addressed through various Information and Communication Technologies (ICT) driven activities which help learners to perform calculations efficiently, to describe patterns and to identify mathematical relationships. Integration of technology - based tools has the potential to upgrade and support teaching and learning in mathematics classrooms. Simin and Wan Athirah Wan (2015) state that the integration of ICTs in education simply involves incorporating and communicating with computers and other technology-based tools in the daily classroom practice.

The use of these technologies leads to more effective learning in all school subjects. The above researchers further argue that the process of technology adoption is not a single step but an on-going and continuous one which needs all stakeholders who are involved in the education of the learners to come on board. The White paper on e-education (DoE, 2004) clearly laid out its goal which stated that by 2013 all teachers and learners ought to be ICT capable. The on-going strategy sought to transform teaching into a developing creative process. It also meant effecting changes in teaching and learning methodology. Teachers and learners were encouraged to access diverse and useful technology tools to benefit the learners educationally.

ICT has become the mode of choice of communication amongst people in all spheres and its use in South Africa has increased (Leendertz, et al., 2013). Many learners in South Africa can now relate to technology - based tools in their homes and in their surroundings. Extending these tools to mathematics classrooms can help raise the standard of mathematics education as this is a priority for the South African Department of Basic Education (DBE, 2012). Innovative teachers in mathematics classrooms can take advantage of its popularity among learners and facilitate interactive lessons to achieve curriculum outcomes. However, it is vital to note that the introduction of integrating technology in classrooms was not meant to phase out other teaching methods or to replace the teacher. Simin and Wan Athirah Wan (2015) believe that technology tools are not meant to replace quality teachers in the classroom but instead they are considered as an add-on supplement needed for better

teaching and learning. It was rather promoted to bring a balance in the teaching environment and for the improvement of the South African child's learning. It is essential that these tools are integrated in current mathematics lessons for the benefit of the learner.

Technology plays a major role in the growth of any country's economy, social and educational status. The researcher believes that integration of technology - based tools in mathematics classrooms supports a learning environment, where a learner is an active participant in his/her learning. The need to make use of innovative teaching approaches and continually updating current methods in the classrooms cannot be ignored (North, Bansilal, & Umugiraneza, 2017). Such innovative methods have the potential to change poor outcomes in mathematics.

## 1.3 General performance of learners in Mathematics

### 1.3.1. Trends in International Mathematics and Science Study

Trends in International Mathematics and Science Study (TIMSS), is an extensive assessment programme measuring and monitoring the performance of learners' key subject areas, science and mathematics. The programme is designed to assess mathematical knowledge possessed by learners. It also measures their problem-solving strategies they use in mathematics, as well as checking procedures used to solve given problems in the Intermediate Phase. This helps to assess the health of the education system of the country. Comparison of education systems is also made possible through such programmes.

It is done on a four year cycle, and South Africa participated in the following years, 1995, 1999, 2003, 2011 and 2015 respectively. In the last assessment done in 2015, forty eight countries participated and South Africa was among the bottom five with a score of 376 in mathematics. The achievement scale which presents an important baseline benchmark is 500 points. The Grade 5 level performance was also below 400 points. These scores clearly show how our learners are underperforming in gateway subjects which are key to the economic growth of the country.

In a media statement, the Minister of Education Angie Motshekga, announced the strategies put in place by the Department to improve performance of learners. Among them was use of the common textbooks which would be distributed by the Department to all government schools. Improving technical expertise in mathematics and science and technology also was a priority. This would be achieved with the assistance of Japanese and Korean Institutions.

### 1.3.2 Eastern Africa Consortium for Monitoring Educational Quality

The Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) is a major cross national research study. Its purpose was to assess the provision of education in primary schools, conditions of schooling and making use of standardised surveys to assess learners' performance in mathematics and literacy. Such surveys help with providing educational officials and researchers with technical skills for monitoring and evaluating different education systems. They also help with policy formulation which may help to improve performance in both mathematics and literacy. Achievement results for both literacy and mathematics in 2007 showed that South Africa underperformed in both subjects compared to the SACMEQ average (Spaull, 2013).

### 1.3.3 Annual National Assessment

Standardised National Assessment highlights how education systems are generally performing. These assessments were a pointer of weaknesses encountered both in mathematics and English. Annual National Assessments administration aimed at dealing with these weaknesses, addressing and turning them into strengths. In South Africa ANA assessments were introduced in 2012. This tool was put in place to check how the schools were performing against other schools nationally. It was developed by the Department of Education (2011) with the aim of providing new interventions to deal with English and mathematics challenges.

The Department of Education set and supplied assessments to all schools which in turn conducted and marked the assessments. Moderation was done at district level. In mathematics, Intermediate Phase learners (Grades 4, 5 and 6) obtained below forty percent in three consecutive years, 2012, 2013 and 2014 (DoE Report 2015). Assessments were done in mathematics and English. Due to administration challenges ANA was last administered in 2014, however it gave the nation a clue on how learners perform in mathematics.

## 1.4 Policy on ICT

South Africa's constitution clearly spells out that the state will provide basic education to all its citizens. Since democracy, the White Paper on e-education, an ICT (Information and

Communication Technologies) policy was put in place in 1994 to promote ICTs in schools (Blignaut, Hinostroza, Els, & Brun, 2010). The policy states that:

> *Every South African manager, teacher and learner in the general and further education and training bands will be ICT capable (that is, use ICTs confidently and creatively to help develop the skills and knowledge they need as lifelong learners to achieve personal goals and to be full participants in the global community by 2013 (DoE, 2004 p. 17).*

Integrating technologies seeks to develop learners who will fit well in the society, be productive in the workplace and be willing to learn new technologies as they are introduced. Technologies are not only for people in towns but for all South Africans who deserve to be technologically literate and as such the government has a duty to offer technological resources and train its people to use them effectively.

Mdlongwa (2012) describes ICT as a global network in which ideas are exchanged and information and knowledge are shared, through using devices like cell phones and computers to connect people. In the same policy teachers are encouraged to improve teaching and learning practises and to obtain gateway to ICT resources to enhance curriculum delivery.

In the early years of democracy, the education system faced several challenges. These included, high dropout rates, high absenteeism levels, low pass rates at Matric level to mention just a few. Education had to be restructured to cater for all. Evoh (2007) suggests that historical experiences of the educational system during apartheid stifled human capital development among South African generations. This impacted the growth of ICT use negatively. One way of furthering teaching and learning was through adoption of ICTs in schools. The White paper policy was to drive how ICTs would be incorporated into the curriculum.

According to the Department of Education, ICT usage was prevalent in urban areas rather than in the rural areas. During the early years of ICTs there was a digital divide, which is the gap between people who had access to technology and those who did not. The gap had to be closed, however it has taken a long time to do so.

Initially, computers were introduced to well-resourced schools where they were primarily used for the purposes of administration. Later, this changed to use of technology tools to

improve the quality of teaching and learning. The government together with non-governmental organisations like INTEL, SCOPE and School-net tried to promote technology integration. As mentioned earlier the progress was very slow as technology was mainly used for administrative purposes.

## 1.5 Focus of the Study

Mathematics drives all human development and is an important part of human culture. Professions such as engineering, medicine and chartered accountancy are all mathematically driven. South Africa will not be able to compete with the rest of the world in terms of economic growth if mathematics results do not improve. As an Intermediate mathematics educator, it is of utmost importance to contribute to the improvement of poor performance in mathematics in South African primary schools hence the need to explore integrating technology - based tools into mathematics. Several researchers have identified reasons why learners perform poorly in mathematics and further suggested what needs to be done in order to improve this. In this study, not all reasons for poor performance in mathematics have been discussed in detail, however more focus was zoomed into teaching mathematics using technology - based tools.

The Technological Pedagogical Content Knowledge framework (TPACK) has been found to be very useful in teaching and learning mathematics (Mishra & Koehler, 2006). TPACK is defined as the convergence of three types of knowledge; mathematics knowledge, knowledge of technology and knowledge of teaching and learning. This framework is said to consider teachers' knowledge of the subject matter as well as establishing habits of teaching and learning. Technological knowledge then helps the teacher to represent the content in new ways which assist the learner in grasping concepts easily. It was the researchers desire to identify technology tools in Intermediate classrooms and explore how teachers use the tools in a beneficial way.

One of the visions of the Department of Education (DoE) is to improve learner performance in mathematics in schools. It also seeks to develop a well-educated, skilled and developed citizenry (Department of Education, 2011). ICT, pedagogy and the role of the teacher have become relevant in supporting and enabling this vision to come true. Much research has been done on helping the learner to grasp mathematical concepts in the Foundation Phase (Grades R - 3) and the Senior Phase (Grades 7 - 9). However, a gap still exists as not much research has been geared towards supporting the Intermediate Phase learner. The

researcher's focus was mainly on identifying technology - based tools which are currently being used in the Intermediate Phase mathematics classrooms and how these are integrated within the teaching of mathematics.

## 1.6 Significance of the study

Integration of technology - based tools in mathematics lessons cannot be overemphasised. It supports the goal of the Department of Education which sought to turn all schools to e-schools by 2013. The White paper on e-Education states that by 2013, all South African learners ought to be ICT skilled, use ICT confidently and creatively to help develop the skills and knowledge they need to achieve full potential and be competent contributors worldwide (DoE, 2004). Currently, this goal is far from being accomplished due to lack of resources, in both urban and rural South African schools. Leendertz et al. (2013) concur that use of technologies in South African schools remain dismally limited. The researcher believes that it is an ideology that cannot be ignored in the South African education system. Integration of such tools calls for training of teachers to keep abreast with new knowledge and produce competent mathematical learners. It also seeks to produce learners who will be proficient in the work environment, contributing to the growth of the South African economy (Hart & Laher, 2015).

It was significant to identify technology - based tools currently used in mathematics classrooms in order to share information with teachers and the Department of Education for planning purposes. Findings of the study will be used to educate and support other teachers who are not yet integrating technology into their lessons. Furthermore, it will help the learners to be more involved in their learning and actively participate in their education (Adamides & Nicolaou, 2004). The researcher believes that clear policies and support across all levels of the education system makes the implementation of technology integration easier and feasible.

## 1.7 Rationale of the study

***"If we teach today's students as we taught yesterday's, we rob them of tomorrow".***
***Don Dewey***

Common practices in mathematics classrooms where teachers are still utilising traditional teaching methods include learning through memorisation, reciting concepts and teaching a procedure. It also involves giving examples of a concept, showing learners how it must be applied and then setting exercises on the chalkboard for learners to complete (Grabe & Grabe, 2004). Some of the most frequently adopted activities by mathematics teachers were teacher lectures, practise skills and procedures. A social constructivist approach believes that a learner is not a passive receiver of knowledge but rather an active participant who plays an active role in his / her own learning (Soobik, 2014). With innovative teaching methods having the potential to positively contribute to learning of mathematical concepts, the researcher believes that it is high time teachers take up this challenge in a bid to help the learner perform better in mathematics.

Having classroom practitioners who are already using technology - based tools to teach mathematics affords us an opportunity to learn and share information. Teachers as curriculum implementers must be willing to adapt to new changes in the education system. They should work towards reaching the government goal of producing highly skilled learners who will be able to take up professions which contribute towards a better South Africa. This study has been conducted to benefit fellow mathematics teachers in South Africa, mathematics subject advisors and all people interested in teaching and learning of mathematics in primary schools.

## 1.8 Research objectives

1. To explore which technology - based tools are integrated into mathematics classrooms and why they are being used.

2. To explore how technology - based tools are integrated into mathematics classrooms.

## 1.9 Research questions

The critical questions of the study are:

1. Which technology - based tools are integrated into mathematics classrooms and why are they being used?
2. How are technology - based tools integrated into mathematics classrooms?

## 1.10 Explanation of key words

### 1.10.1 White paper on e-Education

The South African government is concerned about quality education for economic growth and social development for all its citizens. The goal of the policy is that all South African learners in General Education and Training Band (GET) and Further education and Training band will be ICT capable which means that all learners ought to be able to use ICTs confidently and creatively in order to develop skills. Such skills and knowledge would enable learners to achieve personal goals and to be full participants in the global community. According to the White paper 7 on e-education (2004 p. 9-48), the Department of Education strongly believes that developments in ICT:

- Create access to learning opportunities
- Redress inequalities
- Improve the quality of learning and teaching
- Provide opportunities for individualised learning
- Accommodate different learning styles

The use of ICTs could enhance educational reform, by enabling teachers and learners to move away from traditional approaches to teaching and learning (DoE White paper 7). Bos (2017, p. 437) argues that teachers should be aware that in technological environments, various techniques can change delivering of mathematics lessons into a purposive and joyful activity. It is vital that reinforcement of other effective teaching practices is taken into consideration. Technology - based tools should be incorporated in current teaching practises in order to achieve desired results in mathematics.

### 1.10.2 Technology integration

Technology integration is described as incorporating technology and technology - based practices into all aspects of teaching and learning specifically incorporating appropriate technology in objectives, lessons and assessment of learning outcomes (Wachira & Keengwe, 2011).

Ramorola (2013, p. 656) described technology integration as, “bringing together or combining technology with teaching and learning strategies in order to meet the curriculum standards and learning outcomes of each lesson, unit or activity”.

Other researchers, Redmann and Kotrlik (2004) argue that technology integration is making use of different technology tools to enhance and support teaching and learning in the classroom. It is inclusive of computers, interactive media and the internet.

Drawing from the above-mentioned definitions and for the purposes of the study technology integration will be described as use of technology-based tools to support learning and teaching in order to achieve learning outcomes set for a particular lesson.

### 1.10.3 Educational technology-based tools

According to Majocha (2015) technology - based tools are instructional tools for delivering content to learners in an integrative fashion. Technology tools are specifically used for educational purposes in order to facilitate learning. Educational technology tools improve performance by creating, managing and using appropriate processes and resources. For the purposes of this study, technology tools include computers, laptops, tablets, interactive whiteboards, overhead projectors and other forms of technology that are used in the classroom. Technology plays a distinct role of supporting a process of teaching and learning in education. Technology tools are not content deliverers on their own but merely tools which help the child to construct knowledge and create meaning out of abstract concepts.

### 1.10.4 Technological Pedagogical Content Knowledge

- **Technological Content Knowledge**

Technological Content Knowledge (TCK) describes the reciprocal relationship which exists between technology and content. Technology affords teachers ways of representing certain content in new ways. This helps learners to realise the relationship which exists between different concepts simply by touching or playing with these concepts on technology - based tools (Mishra & Koehler, 2006).

- **Pedagogical Content Knowledge**

Pedagogical Content Knowledge (PCK) means that effective teaching requires more than separate understanding of content and pedagogy. It further acknowledges that different content lends itself to different methods of teaching. It stresses the importance of realising the interplay which exists between content and pedagogy (Mishra & Koehler, 2006).

- **Technological Pedagogical Knowledge**

Technological Pedagogical Knowledge (TPK) identifies the relationship which exists between technology and pedagogy. This knowledge helps the teacher to select the right

teaching approaches and the appropriate technology tools for delivering various lessons in the classroom (Mishra & Koehler, 2006).

- **Technological Pedagogical Content Knowledge**

Technological pedagogical content knowledge is a framework which emphasises key knowledge elements which are required for effective integration of technology into teaching. It reinforces that several issues must be considered when technology is being introduced into teaching and learning. Its emphasis is on integration with pedagogy rather than to focus on technology (Mishra & Koehler, 2006).

- **Intermediate Phase**

The General Education and Training band (GET) is subdivided into phases called the Foundation Phase (Grades 0, 1, 2 &3), Intermediate Phase (Grades 4-6) and the Senior Phase (Grades 7 -9). The Intermediate Phase is the middle phase of formal schooling in primary education in South Africa. It comprises of Grades 4, 5 and 6 (Department of Basic Education, 2012).

## 1.11 Organisation of the study

The study is organised into the following seven chapters

### 1.11.1 Chapter One – Introduction of the study

Chapter one introduces the study and its content. Presented in chapter one is the background of the study, focus of the study, significance of the study, rationale of the study, research questions, research objectives and explanation of the key words. The chapter is concluded by outlining the organisation of the study.

### 1.11.2 Chapter Two – Literature review

Chapter two seeks to review relevant literature which supports and guides this study. The researcher highlights new concepts and describes them in detail. In this chapter the researcher drew attention to local and international studies that have been carried out on integration of technology in mathematics lessons and further highlighted the existing gap.

### 1.11.3 Chapter Three - Theoretical framework

Chapter three outlined the theoretical framework employed for this study. The focus of this chapter was to identify the interplay between teacher's knowledge of mathematical concepts

and the ability of the teacher to integrate technology into mathematics lessons. The researcher reflected on the TPACK framework in detail.

### 1.11.4 Chapter Four - Research methodology

Chapter four presents and describes data collection methods that were used in the study. Rationale for methodology selected for the study is clearly set out. The researcher used qualitative research, a holistic approach which seeks to focus on human experiences. In order to gather data, Grades 4 to 6 mathematics teachers at Toyland School were obtained through purposive sampling. The researcher generated data using questionnaires, observation of lessons and conducting interviews. The following sub-headings discussed in this chapter include the design of data collection instruments, location, ethical consideration and informed consent. Research design is justified in this chapter and trustworthiness of the study is illustrated.

### 1.11.5 Chapter Five – Data Analysis and presentation of findings

Chapter five presents the analysis of the data generated and discusses the study's findings.

### 1.11.6 Chapter Six - Discussion of findings and Conclusion

Chapter six examined and interpreted the findings of the study. Discussion of results is also presented in this chapter as are limitations, recommendations and the conclusion of the study.

## 1.12 Conclusion

Occasionally, education demands appropriate changes. Nowadays our society is trapped in a digital era which allows a changed approach regarding the learning environment, learning strategies and learning resources (Unianu & Pucaru, 2014). Technology - based tools make the content look attractive and appealing to the learners, and makes learning more productive. It is necessary to find appropriate ways of using technology to make teaching and learning more meaningful. Polly (2014) argues that many researchers investigating the use of technology in education have found that technology is most powerful when used as a tool for problem-solving, conceptual development and critical thinking. In order to improve performance in mathematics, the Intermediate Phase teachers must be encouraged to make use of technology - based tools.

# Chapter Two

# Literature Review

## 2. 1 Introduction

The use of technology to enhance teaching and learning is becoming increasingly predominant. Several technological developments have touched every aspect of our lives as citizens of South Africa. Technology is not only bound to the workplace, but rather found in almost every transaction of our daily lives. Its use in the home, in the business world, in the sports field and in education has greatly increased and it seems this trend will continue (Mdlongwa, 2012). Young people, including learners have found technology very appealing and given a chance, they would most probably engage with it. This is one of the reasons why it should be included in every classroom and be utilized to improve teaching and learning.

Mathematics education has become one of the national priorities in South Africa (Stols et al., 2015). In the same way, Hart and Laher (2015) state that integrating ICT's is also a priority for the South African government. Underperformance in mathematics has been the concern of the majority of South Africans concerned about the future growth of this country. Learners in both primary and high schools have not been able to achieve good results in mathematics assessments, clearly indicating lack of understanding of mathematical concepts. The National Development Plan (NDP), a long term plan, highlights educational objectives and strategies for improving the education system. In the long term these strategies assist in eliminating poverty, raising economic growth and building a developmental state. The ninth chapter of the NDP specifically deals with improving education, training and innovation (Penniston, 2016). One of the objectives is to improve performance, thereby increasing the number of learners achieving above fifty percent in both literacy and mathematics.

In 2012, the Minister of Education laid out plans to better education standards which included, administering Annual National Assessments (ANA) in mathematics and english and introducing the new curriculum policy (CAPS). Such strategies were aimed at dealing with learners' underperformance in gateway subjects like mathematics and English. The country's economic growth depends largely on the education of its citizens. It has become necessary to think deeper and find remedy for underperformance in mathematics. One of the emerging teaching approaches employed in schools is the use of innovative methods in the classroom, which includes integrating technology - based tools into mathematics lessons. Initially, the idea of using technology was not welcome by many stakeholders, however as people received more education on the subject, technology use became more welcome.

There are a number of challenges faced by mathematics teachers in South Africa with regard to the teaching of the subject. Stols et al. (2015, p. 1) suggest that one of the "current critical challenges faced by teachers in South Africa and many other economies with emerging and developing economies relates to their own lack of mathematical content knowledge, and the skills required to apply what they know in the classroom". This is confirmed by the SACMEQ 111 report, (2012) which indicates that South African mathematics teachers have a limited understanding of the curriculum content they are required to teach. With technology integration, it is vital to note that technology use is not meant to replace the teacher in any way, however whenever these tools are successfully incorporated into lessons they maximise students' learning experience (Bester & Brand, 2013). Research shows that implementation of technology in classrooms still lags in other parts of the country, especially in rural areas. This is simply because the government did not prioritise it as compared to promoting necessities like sanitation, electricity and providing people with clean water.

It is also a fact that the legacy of inferior mathematics education offered during apartheid to most learners is still prevalent in some schools especially the public schools. This simply means the quality of teaching and resources may be inferior as compared to that offered in Model C or private schools (Gilakjani, 2013). Furthermore, the researcher suggests that most teachers usually use the same teaching techniques which they experienced themselves, therefore it becomes necessary to expose them to new teaching strategies consistent with reform movements. Most teachers were exposed to old methods of teaching, mainly the chalk and talk method. There is need for development in both content delivery and use of innovative teaching methods. Times have changed and so have the ways of teaching approaches in the classroom.

## 2.2. Learning theories and technology integration

Learning and teaching mathematics with technology is a sophisticated approach which requires the teacher to master a several key competencies (Hong & Thomas, 2015). New technologies are frequently introduced, therefore technology integration requires teachers to be lifelong learners who are willing to be continuously trained to use the tools effectively. Ayoub Cherd (2013) suggests that teachers need to be conversant with new educational reforms as they normally come with new materials, new instructional practices and new behaviours. Important as this may be, the demand may not easily be met by all teachers.

Successful technology integration may not always be easy. It requires the teacher familiarising and having adequate knowledge about the technology tool. Furthermore, the teacher must select the right technology tools, considering the content to be delivered and integrating the technology tool for learning to take place. The researcher believes that teachers who are used to older methods of teaching mathematics may face challenges in integration of technology into their lessons. Negative attitudes of teachers may also hinder use of technology in classrooms. Change is not always welcome and it takes time. To implement successful changes the Department of Education training of Principals, Head of Department and teachers is essential. Teachers also need to make a concerted effort to adapt to new methods of teaching, bearing in mind what is beneficial to the learner. Moodley (2013) argues that South Africa has used old teaching methods that may not have changed for the last few decades. Lecturing, drilling and reciting concepts currently used in mathematics classrooms may not address the challenge of poor performance in mathematics, hence the need for change.

Integrating technology in mathematics classrooms may be viewed from a constructivist perspective. Vygotsky and Piaget's learning theories were further developed from the constructivist theory. Constructivism comes from the word construct or structure. From the constructivist perspective, learning is understood to be a process which is regulated by learners as they construct or build their own knowledge. Constructivists believe that learning is not a passive process but rather an active procedure (Beck & Kosnik, 2006).

## 2.3 Technology Integration

If educational institutions are to fully serve local communities, there is need for them to enhance the digital developments in order to meet the demands of the current expectations. The South African government, together with the Department of Education recognise the potential of technology to improve the quality of education (van Niekerk & Blignaut, 2014). This thought is in line with policy on ICTs which points out the possible development and growth in all sectors if the curriculum is integrated with technology. Growth becomes visible in schools, in the industry sector and in small and large enterprises. Developed countries like the United States have invested in purchasing technology related resources such as interactive whiteboards and hand-held devices to impact education positively (Polly, 2014). This is also the case in developing countries trying to better their education systems. Polly (2014) records that in developed countries, most primary school teachers still find it

challenging to integrate technology in a worthwhile manner. This may also be the case in developing countries, and to be precise in South African primary schools.

Research conducted by the Khanya project revealed that integration of technology in most so called disadvantaged schools is far from a tangible reality (Sabiescu & van Zyl, 2016). This government backed project was undertaken from 2008 with the aim of initiating access to technology in all South African Schools. The progress was slow and not all schools had technology - based tools. Despite these challenges there has been rapid growth of technology integration into teaching and learning institutions worldwide. It is not surprising that recently trained teachers, who are in contact with these tools everyday may advocate for their use in classrooms simply because they have become acquainted with technology during their training years. Several teacher training institutions across the country have since incorporated technology components in training curricula (Sabiescu & van Zyl, 2016). There is need for teacher development in ICT in the entire South African education sector especially teachers who have already been in the classroom. Insufficient financial resources may hamper the growth of integration of technology in classrooms.

Technology - based tools for mathematical learning includes mathematics-specific technology - based tools and general purpose technology - based tools. Mathematics-specific technology - based tools include tools with mathematics software (such as spread sheets), internet sources and other websites which focus on the teaching and learning of mathematics as a subject. General purpose technology - based tools include productivity software (such as presentation software), interactive white boards and general software which suggest that in mathematics classrooms both can be used to effectively teach mathematics (Johnston, 2012).

Technology integration is not simply providing teachers with iPads and encouraging them to use them in class as this may not necessarily translate into expertise on their effective use. It is far more than that.

Technology integration is described by (Keengwe 2013, p. 4) as, “the inclusion of technology - based tools into all aspects of teaching and learning. Integration of technology - based tools also takes into consideration the best practices used in the use of the tools.” This is done in consideration of objectives for the particular lesson and takes into consideration assessments and also learning outcomes. He further explains that technology, in the context of teaching and learning mathematics includes computers with appropriate

mathematical software, online discussion boards and Java tools. Applets on the internet allow students to interact with mathematics problems. Other technologies include dynamic software such as those used in geometry and data analysis that allow for interactivity. The above definition may simply be unpacked as tools which are incorporated during mathematics lessons in order to assist the learners in grasping mathematical concepts. Such tools may include handheld devices with a variety of software. This is a general definition applicable to worldwide classrooms.

In this study, technology - based tools used in South African schools will later be discussed however, it is vital to note that focus will be on how these tools are integrated and not solely on the software. As Keengwe (2013) gives insight to technology integration, he brings to our attention that technologies on their own, are not deliverers of content and cannot supersede classroom practitioners. It is easy to be under the impression that technology does all the teaching and therefore diminishes the need for the teacher. In fact the teacher is the one who identifies the right tools for the content and strategizes how the tool will be used to assist the child to form concepts. These tools are provided to assist the learner in creating knowledge. They are used for transferring knowledge from the world (through instructors) to the learners.

On the other hand, Majocha (2015) describes technology integration as an instructional tool. She further records that using it in an integrative fashion is an instructional strategy. In simple terms technology integration is tool for delivering content to the learner. Integration ranges from simply having access to a variety of technology - based tools ranging from minor and simple uses to advanced uses, which may include multimedia projects or broadcast live online. Researchers emphasise that the focus should not be given to the technological tool itself but rather as a means of creating the end results which is grasping of concepts in mathematical environments.

A lot of research on the subject has been carried out, however the focus is mainly on high schools. Only a few researchers have dealt with use of technology in primary mathematics classrooms. One of the reasons may be that the Department of Education's aim is to improve Grade 12 mathematics results. This becomes a challenge in the sense that if the foundation is not strong enough, in this case primary school mathematics, not much improvement can be expected in high schools. It is high time we acknowledge the importance of improving mathematics performance in primary schools.

Internationally, much research has been done on technology integration especially in developed countries like the United States, Australia to mention just a few. The research largely seeks to establish teachers' attitudes towards technology use and the benefits of using technology in general and a few researchers do focus on mathematics. Teachers' attitudes have been found to play a crucial role in successfully implanting technology in the classroom (Fu, 2013). In developed countries, use of technology - based tools like iPads begins at an early age right up to higher grades. Considering that in South Africa learners play with technology - based tools from infancy, it therefore would make sense to use technology - based tools right from the Foundation Phase in primary schools (funds allowing). This research's findings seek to contribute to the knowledge of technology - based tools in Intermediate Phase mathematics classrooms and how these tools can be used significantly.

## 2.4 Technology in Mathematics classrooms

Teaching and learning in today's classrooms is transforming to meet the changing demands of the society. One of the biggest changes experienced by both teachers and learners is the introduction of technology - based tools to aid teaching and learning. Technology is not new as is has been there for the past centuries, for example the use of calculators, chalk and chalkboards. However new technologies like smartboards, computers and iPads have taken education systems by storm and cannot be ignored (Anderson, Minshew, & Brown, 2015). This seems to be complicated to teachers even though young people do not find it so. In most cases, learners are leading adults in operating the technology - based tools, both in the home and at school. Learners are fascinated by technology, as they are found on almost all social networks like WhatsApp, Facebook, Twitter, Instagram and many other networks.

It does not take long for learners to master how to operate these tools which helps them to be connected to each other and to know what is trending. Considering that technology is of interest to them, these tools can be vehicles for teaching mathematics, which is viewed by many learners as a challenging subject. Several modern technologies, like the smart phone have mathematical games which are enjoyed by learners. While engaging with these games, learners solve problems without realising that they are doing mathematics. The curriculum offers topics with abstract concepts. These can be tackled better with the use of technology tools to assist learners understand better. In order to understand mathematics from primary schools, teachers must be innovative, creative and be open to new ways of teaching.

In conclusion, integrating technology in mathematics classrooms is said to expand access to education in general (Fu, 2013). Through these tools learning may occur anytime, anywhere allowing the learner to interact with one another and with the teacher in a meaningful way. In their study, Sarah et al. (2009) further mention that learners are authorized to make decisions regarding their own learning. Several learning resources are available on the internet allowing the teacher and learners to acquire abundant knowledge through video clips (Khan Academy and many more), audio sounds and visual presentations. The Khan academy has produced high quality short video tutorials around different mathematics topics. There are many more benefits which will be further discussed in this study.

There may be some concerns with regard to technology use in the classroom, especially the internet. The prevalence of undesirable websites showing harmful content like pornography, security to access of information and openness of the web may put students in an exploratory mode. Some researchers believe that misuse of technology will impact negatively on teaching and learning. All these concerns may not be ignored looking into the teacher to pupil ratio and the age of learners in primary schools. It therefore calls for vigilant teachers who try to learn more about these tools and are willing to get training on how to overcome various challenges.

## 2.5 Factors influencing integration of technology in Mathematics classrooms

Many governments have initiated and invested in teaching and learning with technology - based tools. The plan included upgrading the school infrastructure and equipment to accommodate technology integration. Despite these initiatives, several schools are not yet integrating technologies into their lessons, and there is no evidence that technologies are being used (Ramorola, 2013). Those who do, still face challenges and may not yet be fully operating these tools for teaching and learning, especially in mathematics. Researchers have established several barriers influencing the integration of technology into teaching and learning. These barriers may be tackled if the government, the Department of Education, the leaders of learning institutions and teachers work together and have the same goals regarding technology integration. Technology - based tools are powerful tools with the potential to build mathematical strength in each learner, right from the schooling age up to the working environment. Teachers need to be mindful of the fact that these tools can assist them in delivering creative and purposeful mathematics lessons. As such the Department of

Education must strive to create and design technology environments where new teaching practices are reinforced.

Information Communication Technology (ICT) transformation in education around the world began in the 17th century and since then, it has adopted various methods to help teachers in classrooms (Mdlongwa, 2012). Now, in the 21st century, the education system requires teachers and school administrators to apply new information and communication technologies that will provide knowledge to practice their abilities and skills (Raman, Ismail, & Thannimalai, 2019). Technology use does not end in the classroom, its continued use is further extended to the industrial world as it has also transformed. Technology use has increased worldwide and almost every production makes use of technology at some point. Day (2013) says even though ICT has been available for many years, the primary uses are still for demonstration, and drill and practice rather than in the development of mathematical concepts and higher order processes. It is only now, in the 21st century where technology is viewed as a tool that can enhance learning rather than just being used for administrative purposes in schools.

In his study, Polly (2014) believes that educational technologies have been advanced as potential vehicles to reconstruct teaching and learning. The same researcher documents that primary school teachers still struggle to make use of technology - based tools in several meaningful ways. Successful technology integration is dependent on the interplay between teachers, their students, the technology tool being used and mathematics content that they are teaching. This means that the teacher needs to know his/her learners and identify proper technology and pedagogy to be used for teaching a particular content. Focus is not only on the tool but it is further extended to how it will be used to improve the quality of teaching and learning of mathematics. Technologies are not deliverers of content, but tools that educators and students use to construct knowledge and share meaning. The use of technology and cultural tools to communicate, exchange information and construct knowledge is fundamental in the learning environment. Vrasidas and McIsaac (2001) believe that technology - based learning occurs when learners make use of technology - based tools as mind tools that enable them to represent what they know and organize their knowledge in meaningful ways. Mind tools are defined as tools that aid and extend the user's thinking abilities and can be used for knowledge construction and problem-solving. Several

teachers in developing countries may be willing to integrate technologies into their lessons but may find the process challenging due to many barriers that exist.

Reasons for lack of successful integration have been revealed by different researchers, including the ones mentioned above. The researcher will discuss some of these barriers below, especially those that affect South African classrooms. Several studies identified factors that impact negatively on the use of technology - based tools in the classroom. These included the resistance to change by teachers, teachers' negative attitudes towards use of computers, constraints or lack of training and support towards teachers, high cost of the technology tools, lack of access to the right types of technology, inadequate hardware and software and also not having access to the essential technology tools, acquainting themselves with and implementing the tools effectively. A few factors will be discussed in detail below.

The barriers that impact the integration of technology based tools are identified by Wachira and Keengwe (2011) who classify them as external and internal barriers. External barriers which are considered to be first order include lack of equipment, unreliable equipment, lack of technical support and resource related issues while the second order barriers include both school level factors (organisational culture) and teacher level factors such as beliefs and attitudes about teaching technology and openness to change. In their study, Stols et al. (2015) further identified external and internal challenges that potentially kept teachers from regularly using technology during mathematics instruction. They cited that inhibiting factors, include unreliable electricity supply, classroom migration and the burden of connecting at the beginning of each period, as well as time limitations in terms of both preparation and teaching time. Internally, teachers lacked sufficient computer and software skills. They were also hesitant and in some cases even resistant to migrate from traditional teaching approaches to approaches which are supported by technology.

In light of barriers mentioned above, technology integration in mathematics classrooms may be a challenge for a number of teachers however, solutions to these challenges are a possibility if the goal of improving teaching and learning through the use of innovative methods is shared with all teachers as they are curriculum implementers. In schools where technologies are currently used, integrating them in a haphazard manner simply wastes time that could be used for productive teaching and learning. Training of teachers cannot be overemphasized.

### 2.5.1 Limited access to ICT

Although technology is widely used in modern society, the education sector is still lagging. Most schools, both in urban and rural areas have not fully understood the idea of enhancing teaching and learning using technology tools especially in mathematics classrooms. Many South African rural schools have poor infrastructure and are not well resourced. Improving the standard of teaching and learning in farm schools was planned and inscribed in the National Framework for Quality Education in Rural areas. There is need to give priority to these improvements in order to be in line with the rest of the world's standards.

As mentioned earlier, not all South African schools have introduced technology tools into their classrooms. Urban centres are much better in comparison with their rural counterparts. South Africa has public schools, former Model C schools, private schools and independent schools. Schools are grouped into five quintiles according to their resources and wealth of their surrounding communities. Quintile 1, 2 and 3 schools (often referred to as non-paying fee schools) are poor schools which are fully funded by the government whilst Quintile 4 and 5 are the least poor. Focus should be given to most public schools which are generally poor and have insufficient resources as compared to former Model C schools.

### 2.5.2 Rural Schools versus Urban Schools

As stated above, most schools in rural settlements are underdeveloped in terms of infrastructure and resources. Firstly, governments in developing countries are still focusing on providing people with sanitation, electricity and supplying schools with qualified teachers. Schools are still not enough to cater for all learners in the rural communities, which is evident in learners having to walk long distances to get education.

The use of technology began in urban centres where there is electricity and where people are more educated. New developments take more time to be successfully effected in rural areas compared to urban areas. With no electricity, nothing much can be accomplished in terms of technology. For those technologies that require internet connection, there is a very poor network. Rural schools also face a challenge of inadequately qualified teachers. It may become a challenge for someone who is not qualified to grasp integrating technology. Currently, the Department of Education cannot focus on technology integration if they are still struggling with providing schools with trained personnel. Most people prefer working in urban centres especially the young people hence the shortage of qualified teachers in rural

areas. However, there is a noticeable contribution from Non-Governmental Organisations with regard to upgrading rural schools technologically in different parts of the country.

In urban centres, use of technology depends largely on technology availability. As mentioned above, some schools in urban areas are also poorly resourced especially those belonging to Quintiles 1 to 3. This may be due to apartheid practices which did not cater for equal service provision in different racial schools. The availability of computers and other technology tools in schools does not guarantee their effective use (Smith, Kim, & McIntyre, 2016). It further goes to proper utilisation by an institution. This happens after users have embraced the idea of integration and are willing to learn using the new tools for effective teaching and learning to take place.

### 2.5.3 Rigid teaching methods

Teaching methods play a large role in the learning environment. Effective learning takes place in an environment where the learner's attention is captured. One of the main considerations for a successful lesson is a method of teaching used by a teacher to deliver content to the learners. In mathematics classrooms, it is quite normal that a teacher uses old methods to which the teacher him/herself was exposed. Wachira and Keengwe (2011, p. 24) concurs with the above statement when he states that, "teachers generally teach the way they were taught and infusing technology - based tools into instruction poses unique challenges to instructors who lack the technology or don't have the knowledge and skills to teach with technology." Many teachers teach mathematics in abstract forms which impacts negatively on the understanding of mathematical concepts. Poor results in mathematics lead to question the effectiveness of mathematics teaching. Looking at how mathematics teaching could be made more effective, a crucial issue is that of the actual methods of teaching employed by teachers to facilitate teaching and learning. Teachers need to continually revise existing teaching approaches in mathematics. Innovative teaching approaches enable learners to link mathematics to real life and prepare learners to be investigators and problem solvers (North et al., 2017**).**

Soobik (2014, p. 71) believes that, "the approach to teaching methods is highly dependent on teachers' readiness and abilities to apply innovative teaching methods". Other researchers further note that when teachers are considering teaching methods, the chosen method must be relevant in fulfilment of educational objectives, content being taught, readiness and

abilities of learners (Jones and Compton, 2009). This simply suggests that teaching methods are vital in the delivering of content. Even with technology use teachers need to carefully plan how the tool will be used to deliver content.

Bester and Brand (2013) agree that any teaching method must attract the learner's attention and should cater for different learners during a lesson. In this context, the use of technology would certainly be an option to consider. Capturing the learners' attention is very important and cannot be ignored in the classroom. Integrating technology into lessons, believed to be one of the innovative methods must enable the use of technology in diverse ways in order to catch the attention of learners. Teaching methods can be grouped into two categories, the traditional teaching methods and the innovative methods which are currently promoted for teaching today's learners. Traditional teaching methods are more teacher-centred rather than learner-centred and may include lecturing to students whereby the teacher does more talking and most concepts are taught in an abstract manner. Learners do not have room to be critical thinkers and therefore fail to interact with abstract concepts. Other methods include the chalk and talk method, rote learning and drilling concepts causing learners to repeat one line repeatedly.

It is not surprising that most mathematics teachers are using such methods and rote learning is still practised in mathematics classrooms. Learners are made to recite multiplication tables, without fully understanding the meaning of the grouping or multiplication concept. The ideal situation would be to use these methods only when it is appropriate taking into consideration new available teaching methods that will meet the needs of learners. Such traditional methods are a one-size fits all as individual learning needs of students are not taken into consideration. Scholars have established that students learn differently, some are visual learners whilst others are hands-on learners. With a large teacher-learner ratio in South African schools, both traditional and new teaching methods should be used to productively cater for all learners.

Innovative teaching methods on the other hand focus more on the learners and recognise that a learner has something to contribute in the learning environment. The teacher merely provides a conducive learning environment and facilitates learning. Not all teachers have fully understood the importance of using these innovative methods, hence many teachers are still utilising the old teaching methods. The government has brought many initiatives geared towards assisting learners to grasp mathematical concepts using technology tools.

Innovative teaching methods which create opportunities for sustainable development of teaching include, brainstorming, problem-solving and recently technology use has become the talk of the day (Banks, 2009).

Nokwali, Mammen, and Maphosa (2015) are of the view that effective teacher training in technology is an important pillar for successful integration and, implementation and sustainability of ICT in education. Researchers noted that more approaches which encourage learners to be active, give them opportunities to demonstrate creativity and critical thinking skills and such approaches are needed in South African classrooms. Technology - based tools appeal to visual learners. Visual tools stimulate the learning process and are a starting point to achieve interaction in the classroom. This works well, especially in mathematical lessons where teaching abstract concepts leave learners more confused. Stokes (2010) suggested that the use of visual tools assists in uncovering the role that visual reasoning plays in solving problems in mathematics. Naidoo (2011) agrees that the use of colour and other visual tools creates excitement and interest in mathematics classrooms. The researcher further argues that good teachers often use symbols, colour, diagrams and gestures in the classrooms as an alternative to the usual talk and chalk approach. Technology tools seem to offer all these mentioned above, that is, visual, auditory and use of videos which have gestures. In his study, Mosimege (2017) showed a positive and significant relationship with the mathematics performance of learners and further suggested that the way teachers interact with learners during lessons has a significant bearing on their performance.

In conclusion, for learners to have the capacity to participate in today and tomorrow's economy they need to be taught using methods that will assist them to develop mathematical reasoning and problem-solving (Kilpatrick, Swafford & Findell, 2014). It is understandable that innovative teaching methods present their own challenges. Simply ignoring these methods for fear of change will reduce progress in terms of educating learners. Teachers must keep abreast of new developments in the education sector to keep up with changes of the time and consider the 21$^{st}$ century learners.

### 2.5.4 Lack of teachers' technological knowledge and content knowledge

Raman et al. (2019) argue that technology literacy is the teachers' ability to explore and deal with the situation of new technologies in a flexible way. This includes critically selecting, analysing and evaluating data and the right technology in order to build new knowledge.

One of the teachers' roles is fostering awareness and responsibility which needs to be observed by the learner in making use of technology in mathematics.

Johnston (2012) acknowledges that developing mathematical tasks supported by technology is not a casual endeavour. Different ways of supporting teachers with respect to technology included introducing technology in context, addressing worthwhile mathematics with appropriate pedagogy, taking advantage of technology, connecting mathematics topics and incorporating multiple representations. This may not be easy in the beginning but will yield good results at the end if implemented in different learning environments.

Mishra and Koehler (2006) noted that true technology integration, involves negotiating the relationships between the three components, technology, pedagogy and content. These are suggested and elaborated by the Technological Pedagogical Content Knowledge framework. Lack of one of these components, may injure the whole exercise of teaching and learning.

Lack of content knowledge is one of the key areas which needs attention, as without adequate subject content knowledge there is no learning. However research states that teachers spend a lot of time focusing on content teaching hence find little time for developing themselves to integrate technology. The KwaZulu-Natal Department of Education holds several content workshops to enhance teachers' knowledge regarding content knowledge especially in mathematics and English. The workshops are held during June school holidays and once or twice in the school term. Clusters have also been formed so that teachers can collaborate and assist each other with mathematics content. None of these workshops addresses the issue of integrating technology into mathematics lessons. Teachers' collaboration has an impact on teachers' competencies, confidence and attitude towards science and mathematics teaching. Collaboration can also focus on teaching mathematics using different technology tools. Teachers are advised to promote student collaboration through making use of small groups in the classroom (Webb, 2009).

Many researchers investigating the use of technology in education have found that technology is the most powerful when used as a tool for problem-solving, conceptual development and critical thinking. It is therefore paramount for teachers to have technological knowledge in order to enhance learning in mathematics classrooms. Nowadays it is not surprising that learners may operate technology in a better way than the teacher. The learners' world is surrounded by technology from a tender age, hence teachers who lack knowledge in technology may feel inadequate to facilitate a lesson using a

technological tool. Sabiescu and van Zyl (2016) argue that teacher competencies have a big impact in using technology effectively and it eventually affects abilities of learners. Lack of adequate training of teachers in terms of preparing and delivering technology supported lesson plans may result in mediocre lessons. With more training on delivering content using technology, achievement of better results could be evident in mathematics.

### 2.5.5 Lack of technological knowledge in the management personnel

For change to take place in schools, leaders such as subject advisors, Departmental Heads and Principals need to be trained to spearhead integration of technology in classrooms. Subject specialists ought to have analytical and critical thinking and be creative so that they can assist teachers in adjusting to technological changes in the education system. Therefore, advisors should have computer literacy competencies (Raman et al., 2019).

Although teachers are central to technology integration, the school leadership is also a critical component in the implementation of educational reforms, revitalising teachers and improving the state of schools. School leadership needs to facilitate change and support teachers through continuous professional development in both technical and pedagogical issues. Currently, insufficient knowledge that leaders possess hampers advancement of ICT integration. Considering what has been stated above, change must start from top level management all the way down to teachers and students in order to be fully welcomed in the education system.

### 2.5.6 Teachers' attitudes and lack of confidence

Laher (2015) states that while technology provides many new opportunities for issues like learning styles, student-centred instruction and promotion of higher-level thinking, the teachers' attitudes and beliefs often prevent them from fully integrating technology into their course design. The researchers further mention that factors which appeal to teachers to integrate technology in their classrooms include self-efficacy, personal technology use, positive teacher attitudes and beliefs towards technology and access to teacher development in the area. These factors can motivate teachers to use technology in teaching environments.

Researchers (Tsai and Lee, 2014; Fu 2013) claim that successful integration of educational technology in schools is greatly influenced by teachers' attitudes and to some extent, their aptitudes. An attitude is defined as one's perception of an object, which may be favourable

or unfavourable while an aptitude is a natural ability to do something. Thus Hart and Laher (2015) define, 'attitudes towards educational technology' as an individual's perception of computers and educational technology, which may range from being very positive to very negative**.** Teachers may resist integrating technologies based on feelings of discomfort, dislike or fear of technology. Furthermore, since they lack technological skills they may fear losing control and looking stupid in front of learners. According some researchers, factors that are thought to influence teachers' attitudes may include perceived usefulness, perceived cultural relevance, perceived competence and access to educational technology.

Change from the usual way of teaching to the innovative use of technology in the classroom has not been an easy task both locally and internationally. Nokwali et al. (2015) agrees that change, however good, always brings with it scepticism, distrust and possible negative attitudes. Teachers' attitudes towards technology cannot be taken lightly as they play a vital role in its implementation. Ling Koh, Chai, and Tay (2014) concur with the above researchers that teachers' attitudes towards the use of computers in teaching mathematics in the primary school classrooms play a big role. It is important that teachers, who are the implementers of the curriculum work together with curriculum planners and have a common understanding and vision of what the curriculum ought to achieve.

van Niekerk and Blignaut (2014) argue that in many South African schools technology integration simply means distributing computer hardware and software. They further record that integration varies according to individual teaching beliefs, perceptions and attitudes towards ICT uptake. It also depends on their prior experience and how they incorporate technology into their practices. Implementing ICTs has become more complicated and needs teachers who continually update their skills in technology use. The above study confirms that positive attitudes of teachers towards the use of ICT in teaching and its availability would improve teaching of mathematics in schools.

Nouzha El (2013) identified an attitudinal barrier in most African teachers where they regarded the modern mathematics phase as a mistake and deplored the way in which developing countries have copied the developed countries. African governments focused on textbooks, more classrooms and more trained teachers than technology introduction. He further records that innovations in the African education system still meant providing basic education for all, improving performance of the system, resources, access and equity, while

in developed countries it was enhancing teacher capacities and providing appropriate school environments with new technologies. Bester and Brand (2013) believe that although many teachers have access to the internet, they often refrain from using it to enhance teaching and learning.

Boaler (2010) suggests that transformation of classrooms into sites where learners develop a positive mind set and become confident users of mathematics, is a difficult task. This is affected by the attitudes of teachers from the onset as said earlier. Positive teachers who are open to change and innovation are most likely to create such climates. Improved confidence on the use of technology tools in the intermediate phase classrooms can bring a positive change in learners' performance which can be attained through a lot of training by teachers' training institutions and the Department of Basic Education.

## 2.6 Benefits of integrating technology into Mathematics teaching

Research studies previously done in the use of technology in teaching and learning in South Africa, Africa and internationally clearly show the benefits of its use in the classroom. Technology use is referred to by researchers as a novel action seeking to enhance efficiency and productivity of both teaching and learning (Mdlongwa, 2012). Despite its acceptance and popularity, there are still many people who regard technology use in teaching and learning as a waste of time. It is vital to note that many educational institutions in South Africa have used traditional teaching methods for the past number of years and have become comfortable with it. It is also imperative to note that due to uneven GDP (Gross Domestic Product), provinces with high gross domestic product have a better usage of these tools, especially in urban centres. Researchers record that use of these tools in South Africa began in the 1980s, mostly in private schools and a few well- resourced government schools. Mdlongwa (2012) further records that computers were initially used mainly for administrative purposes, such as keeping student records, recording examination marks, producing school reports and creating school timetables. With continuous advancements and developments, a great positive change took place and technology tools were used to turn teaching and learning environments into very productive and beneficial settings.

Technology does not remedy all the challenges faced in the classroom. As with any learning tool, it can be used well or poorly. Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently. This means that its success depends on whether it is appropriately used or not. The focus must be on assisting the learner to grasp mathematical concepts rather than just having the tool in the classroom.

The use of technology is beneficial both to the learner and the teacher. Gone are the days where a teacher stands in front of learners, offloads information and forces it on the learners by repeating the same concept repeatedly. The teacher in today's classroom should become more of a facilitator who guides students to interrogate given data and create their own knowledge for better understanding of concepts. In mathematics classrooms where there is no use of technology tools, drilling of concepts is prevalent. However, now that technology tools appeal to the visual and sometimes auditory senses, learners become more attentive and interested in the topic at hand. Abstract concepts are difficult to master hence the use of these tools helps in that learners concentrate and develop keen interest in what they are being taught.

Teaching with technology tools creates a relaxed atmosphere, where learners can engage with each other and feel free to engage with the teacher. In some instances, the teacher is assisted by learners in the setting up of tools hence making the learning process interactive. When used appropriately, technology can foster effective exploratory environments, stimulate creativity and teamwork while challenging students' problem-solving abilities. Technology can help make meaningful mathematical connections and encourage mathematical discourse. In the past, there was no relationship between teachers and learners, teachers were known to be scary knowledgeable beings whose job was to pour knowledge into the empty headed learners. Learners learn better in relaxed environments where they can share their knowledge with the teacher and other learners. By so doing collaborative learning is promoted and grasping of mathematical concepts becomes a possibility. Bester and Brand (2013) attests that learners tend to concentrate if what they are learning about is interesting. Specifically, the use of technology has enabled students to visualize mathematics, engage in active learning strategies, verify conjectures, build positive attitudes and confidence in their ability to do mathematics (Kersaint, 2007).

Technology integration also accommodates students with different learning needs. Some learners understand concepts better when they hear and see the object under consideration. Visual, aural, kinaesthetic and verbal learners are catered for in mathematics classrooms when these tools are used.

Integration of technology - based tools offers more opportunities to develop higher order thinking skills, which are needed in mastering mathematical concepts. Students may also access information on their own through internet research. Technology integration is learner centred and not teacher centred hence learners are able to self- direct themselves with little guidance from the teacher. Not only do technology tools benefit learners but also benefits teachers, in the sense that they can build relationships with learners and use these tools for assessment. Teachers also have the privilege of making use of mathematical videos posted by other teachers, so as to help learners grasp a mathematical concept easily.

The use of technology tools may also enhance effective teaching and learning in most South African classrooms with large teacher-pupil ratio. Such tools may also be used to motivate learners who need extrinsic motivation. When learners perform well in a subject, their self-esteem is boosted hence, positively impacting their learning.

## 2.7 Conclusion

Mdlongwa (2012) clearly points out that the use of ICT may not be the cure for all the problems that currently beset the education authorities in South Africa, however, research around Africa shows that the use of ICT can greatly influence and improve the productivity and efficiency of both teaching and learning in mathematics. Policies on ICT have not yet been reviewed. There are many new developments that have emerged in recent years and as such need to be taken into consideration. The government must consider putting more finances in technological resources towards teaching of learners in todays' classroom.

Gilakjani (2013) maintain that in order to make a difference and reform todays' classrooms, successful integration cannot be overemphasized. They also mention that integration is not easy as it involves a three step process which requires teachers learning the technology, using the technology effectively and lastly making sure that learning takes place during that lesson.

To ensure effective teaching and learning with technologies, the Department of Education needs to fully train and continuously support teachers in their proper implementation. If all

provinces can receive great support from the District level, more teachers will be willing to integrate technologies being mindful of the support structure that exists should they face any challenges. One other suggestion by Nokwali et al. (2015) is to build technology workshops in each school, where necessary tools could be accessed at any given time. These workshops must always be serviced and maintained to avoid inconveniencing teaching time. Technology integration has found a place in the classroom and can be fully utilised to teach mathematics from primary schools right up to highest educational institutions.

# Chapter 3

# Theoretical Framework

## 3.1Introduction

The modern world is tirelessly challenging teachers to integrate technology into their teaching. Teachers need to develop an understanding of how technology tools can be used effectively to accomplish the purpose of advancing and supporting global educational goals. Leaders in teacher education also have a huge responsibility of setting direction, developing teachers and redesigning teacher preparation programs to accommodate technology integration in classrooms as this may not be an easy task (Graziano, Herring, Carpenter, Smaldino, & Finsness, 2017). After training, teachers must be able to understand the interplay between content, pedagogy and technology. Many studies dealing with the impact of technology tools on teaching and learning have been done in the past and more studies are still underway. Researchers have created several models regarding technology integration. They are still discovering and sharing new knowledge on teaching with technology and how it can assist learners to grasp concepts.

Using technology without really putting much thought into it may not meet the learning goals established by the Department of Education. Researchers, Keengwe & Wachira (2011) have warned teachers against focusing on technology tools, instead, much effort and attention must be diverted to content and different methods of using technology to

deliver content in a better way. Technology advances almost every time and as such, if focus is on the tools rather than on what they can do in the classroom, more time and much energy will be spent on emerging tools giving less attention to the learner. Technology integration is primarily about effective teaching practices, adequate content knowledge and not only about technology itself (Stoilescu, 2015). Teachers should avoid using technology the same way repeatedly as this will not achieve the purpose of technology integration. Mishra and Koehler (2006) created a model that seeks to explain how teachers could integrate technology tools for improving teaching and learning in the classroom. The framework, with its seven components, will be unpacked below.

## 3.2 What is Technological Pedagogical Content Knowledge?

Society needs knowledgeable and competent teachers in the classroom, teachers who are prepared to learn and adapt to new exciting teaching practices. This means there is need of revising old practices of the past which may hinder the learner from exploring his/her own learning. In the past, teacher knowledge could be easily be identified in terms of two areas which are content and pedagogy, however nowadays a third component has been added. With new developments in the education system, a third component which is technology is playing a large role in the teaching and learning environments. In his study Stoilescu (2015), identified multiple difficulties faced by teachers in integrating technologies in the classroom however research on a variety of frameworks which may address this issue are being pursued. While technology can support changes in the way teachers deliver their lessons, Koehler, Mishra, Schmidt & Gurbo (2008) warn that the challenge faced by teachers includes unending requirements which may be sometimes contradictory. In confronting this complexity, all the three components (content, pedagogy and technology) need to be addressed.

Technological Pedagogical Content Knowledge framework is based on Shulmans' (1987) work which proposed that teacher knowledge is inclusive of pedagogical and content knowledge. Shulmans' model consisted of three areas known as Pedagogical Knowledge (PK), Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). In this framework PCK involved knowledge of instructional approaches in teaching a subject in different contexts (Lee & Luft in Luik, 2018). It also involved knowledge of misconceptions

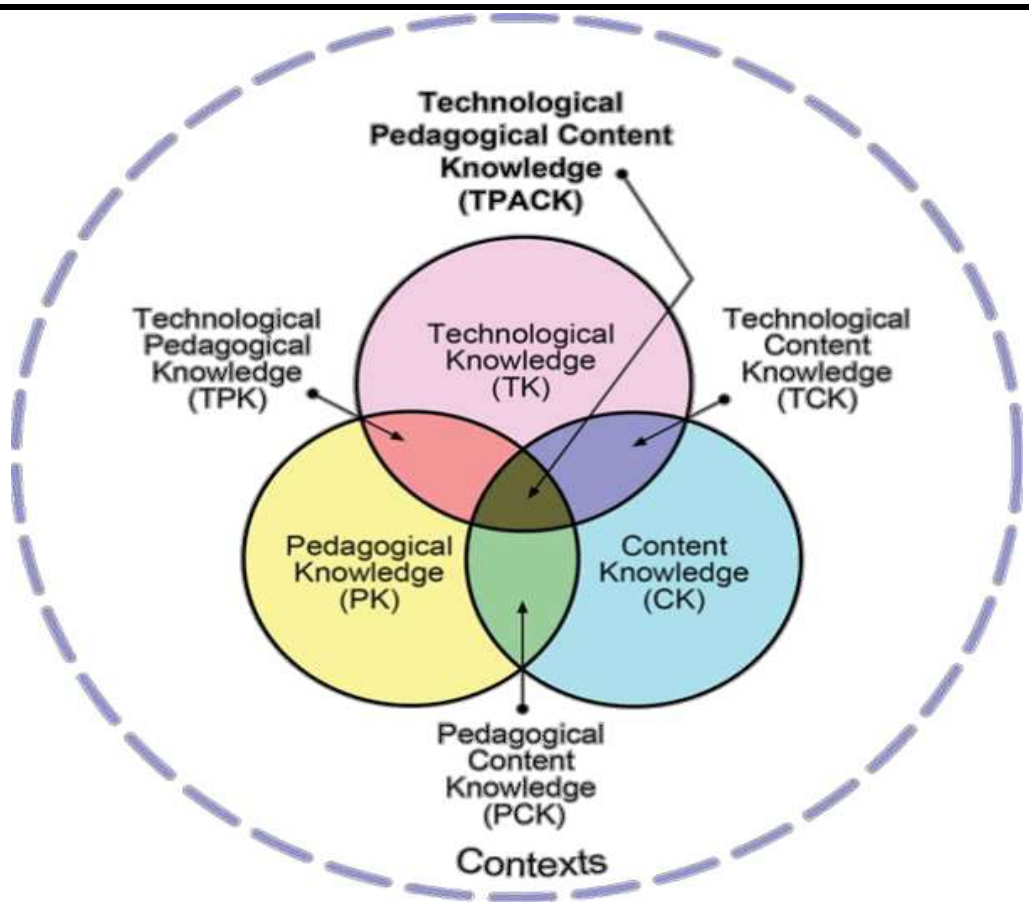
and preconceptions of learners in the classroom. A number of researchers further extended and built on Shulmans' model (1987) in a bid to accommodate the third component, technology.

One of the frameworks commonly used in understanding technology integration is the Technological Pedagogical Content Knowledge (TPACK) model founded by (Mishra & Koehler, 2006). This framework was built on Shulman's work developed in 1987. Mishra and Koehler elaborated on Shulmans' model by adding knowledge of technology to content and pedagogy. They claimed that it is vital that focus be placed on studying how technology - based tools are pedagogically used to teach content effectively. In teacher education, the primary focus should be studying how technology is pedagogically used to teach content (Luik, Taimalu, & Suviste, 2018). The formerly known Pedagogical Content Knowledge model was then named TPACK often presented as a Venn diagram. The model consists of seven parts, with four overlapping parts indicating integration between the three circles.

The TPACK model describes seven unique components which are intertwined Archambault and Barnett (2010), which are:

*Pedagogy Knowledge*, *Content Knowledge*, *Technology Knowledge*, *Pedagogical Content Knowledge*, *Technological Pedagogy Knowledge*, *Technological Content Knowledge* and *Technological Pedagogical Content Knowledge.*

***The TPACK conceptual framework***




*Technological Pedagogical Content Knowledge Framework*

**Figure 1: The Technological Pedagogical Content Knowledge conceptual framework**

**Source: *http://www.tpack.org* p.1**

Giannakos, Doukakis, Pappas, Adamopoulos, and Giannopoulou (2015) state that teachers need to understand how to create appropriate learning activities, to ensure that learners understand the concepts being taught, by using appropriate teaching methods and furthermore effectively integrate technology into the learning process. For better understanding, the researcher will discuss each component below.

## 3.3 Exploring the Technological Pedagogical Content Knowledge Framework

### 3.3.1 Introduction

Current demands in education require more than just a teacher standing and delivering information to the learners. Mishra and Koehler (2009) refer to current times as the age of cool technology tools. Although these incredible tools have been turned and repurposed for educational benefits, this process has not been as simple as it sounds. Different people in different fields notice and appreciate the coolness of the tools, however for us educators it has taken decades to see their "coolness" in terms of being used in teaching and learning environments. A few examples of learning tools include Smart Boards, You-tube, Google, Flicker, to mention just a few. A teacher requires a specific kind of knowledge in order to repurpose and integrate these digital tools. The TPACK framework has seven components which are all intertwined and are dependent on each other, with each component playing a significant role. If one component is missing, it becomes a challenge to integrate the digital tools in a way that is beneficial to the learner.

### 3.3.2 Exploring Content Knowledge (CK)

In order to present content and facilitate a lesson for any subject, teachers must possess adequate content knowledge. In the same way, mathematics teachers have no choice but to have appropriate content knowledge for teaching the subject fluently. Ondes and Ciltas (2018) refer to Content Knowledge (CK) as knowledge, facts, concepts, theories and procedures about the subject matter which must be learned or taught. The researchers further explain it as knowledge of explanatory frameworks that organize and connect ideas of a particular subject. On the other hand, Bingimlas (2018, p. 2) defines it as, "knowledge of subject matter, such as scientific information and mathematics knowledge". Teachers in the Intermediate Phase need to possess content knowledge if performance of South African learners is to improve. Cox and Graham (2009) argue that content knowledge is simplified to indicate a knowledge of the possible topic with specific representations in a given subject area. Furthermore, they pointed to the possibility of how a teachers' knowledge may be independent of pedagogical activities or how teachers might use those representations to teach lessons.

Evans, Nino, Deater-Deckard, and Chang (2015) state that one of the requirements for United States teachers is to obtain a licence that will permit them to teach certain grades. In addition, there are examinations that assess the teachers' knowledge of subject matter and their teaching skills. All this is done to assist teachers in possessing relevant content knowledge. During June, July and August, districts offer specific subject professional

training to reinforce the knowledge of teachers in different mathematics areas. In the Umlazi district in Durban, schools have been grouped into clusters and several content workshops are held during the winter (July) school holidays. Such workshops are designed to assist teachers to grasp content and different ways of delivering it. Research on the causes of poor results in South African schools indicated that most teachers lacked mathematical content knowledge, which impacted negatively on the performance of learners in both primary and high schools. In recent years, a four - year teaching degree is a major requirement for teaching mathematics in primary schools. During training, teachers choose to specialise in teaching in the Foundation or the Intermediate and Senior Phase. It is not enough for a teacher to hold a degree without enough content knowledge for a subject/s he/she is teaching. Content knowledge plays a vital role in the teaching and learning environment and cannot be overemphasized. Mathematics is no exception, any teacher who stands in front of learners in a mathematics classroom ought to possess enough content knowledge to deliver. In South Africa, the Intermediate Phase mathematics syllabus covers five different content areas. Mathematics teachers must possess adequate knowledge on the following content areas.

**Table 2: Mathematics Content Areas in the Intermediate Phase**

| Focus of Content Areas | Specification of content |
|---|---|
| Numbers, Operations and Relations | 1. Whole numbers<br>2. Common Fractions<br>3. Decimal Fractions |
| Patterns, Functions and Algebra | 1. Numeric Patterns<br>2. Geometric Patterns<br>3. Number Patterns |
| Space and Shape (Geometry) | 1. Properties of 2D shapes<br>2. Properties of 3D shapes<br>3. Symmetry<br>4. Transformations<br>5. Viewing of objects |

| | |
|---|---|
| | 6. Position and movement |
| Measurement | 1. Length<br>2. Mass<br>3. Capacity/ Volume<br>4. Time<br>5. Temperature<br>6. Perimeter, Surface area and volume<br>7. History of measurement |
| Data Handling | 1. Collecting and organising data<br>2. Representing data<br>3. Analysing, interpreting and reporting data<br>4. Probability |

**Source: Curriculum and Assessment Policy Statement–Grades 4 – 6, DBE (2011 p. 9).**

A gap in teachers' content knowledge in the key focus areas shown in Figure 3, increases the chances of poor performance in mathematics. Developing teachers' content knowledge cannot be emphasized enough. The Department of Education, teacher training institutions, subject specialists and the school management have a duty to furnish teachers with adequate content knowledge. Graziano et al. (2017) believe that in order to establish professional and influential learning centres there is need of restructuring current practices in various learning organisations. Learning centres are to be vehicles for developing knowledge, skills, norms, values and implementation of TPACK programs.

### 3.3.3 Exploring teachers' Pedagogical Knowledge (PK)

In order to achieve intended outcomes, set in the syllabus, all teachers need a set of skills to help them efficiently organize and manage learning activities. This is named Pedagogical Knowledge. It is vital that teachers understand various teaching methods including the innovative ones which have been largely accepted in the education system. Pedagogical knowledge, which is one component of the TPACK framework, is described by Leendertz et al. (2013) as the expertise of teachers in selecting appropriate methods of teaching content to learners. In other words, there may be many teaching methods available for a teacher to choose from, however, there is need to consider content to be taught. Thereafter, it becomes easier to select the best method for delivering that content which can easily be done if the teacher fully understands how learners learn.

Among other factors, pedagogical knowledge encompasses knowledge of the nature of the target audience, knowledge of managing the classroom, student learning, assessment and other educational purposes (Ondes & Ciltas, 2018). Furthermore, the teacher needs to understand how learners construct knowledge and acquire various skills, how they develop habits of the mind and positive attitudes towards learning (Wachira & Kengwee, 2010). The researcher believes that it is also critical that a teacher fully understands different methods and processes of teaching. During teacher training, teachers should fully grasp various learning theories (cognitive, social and development theories of learning) and how they are applied to learners. One of the most important learning theories which forms the basis of technology integration is the constructivism learning theory (Gilakjani, 2013; Ramozola, 2013) which will later be described in this research. The researcher believes that interactive, relaxed environments where technology is integrated may promote positive attitudes towards mathematics as a subject.

As Fleish (2008) describes primary mathematics in South Africa as being continually in a state of crisis, researchers, Stols et al. (2015) believe that if teachers select the right teaching methods, master adequate content knowledge and then use technology effectively, the challenge of poor performance in mathematics may be solved.

### 3.3.4 Exploring teachers' technological knowledge

Technological knowledge is also another component of the TPACK model which cannot be ignored. In today's classroom if there is lack of technologies, there is a large gap as the world is now technologically advanced. Technological knowledge refers to teachers' knowledge about several technology tools which may range from ordinary technologies such as pencils to digital technologies such as internet, digital videos, interactive whiteboards and software programs (Gumbo, 2018). It requires the teacher to have knowledge of integrating these technologies into the curriculum. Technological knowledge is more than just possessing computer literacy skills however it broadens extensively to application in their daily lives and in work environments. Gone are the days where focus was on teaching and learning parts of the computer and typing skills. It requires fully understanding and mastery of information technology for processing information, communication and problem-solving (Ling Koh, Chai & Tay 2014). It also calls for developmental, open ended interaction with technology taking into consideration that technology rapidly changes and advances continually. While digital technologies evolve rapidly. Niess, Garofalo, and Walker (2009)

believe that effective strategies for technology integration into the learning of mathematics have not changed and as such need to be revised and improved.

The above components (content, pedagogy and technology) interact and connect with each other (Stoilescu, 2015). With training and practice, teachers can possess the above components which can go a long way in assisting a learner in grasping mathematical concepts.

### 3.3.5 Exploring teachers' pedagogical content knowledge

Pedagogical Content Knowledge is consistent with the idea that was conceived by Shulman around 1986 and 1987, which is the idea of pedagogy applicable to teaching specific content. Shulman argued that teachers had special knowledge which set them apart from other professions. He believed that this special knowledge lies at the intersection of content and pedagogy and he called it Pedagogical Content Knowledge. This may be seen when a mathematician may not necessarily be a great mathematics teacher. Koehler et al. (2008) fully explain how a teacher finds different ways of interpreting data to the learner. Pedagogical Knowledge includes knowing what teaching approaches fit the content, and how the elements can be arranged for better teaching. Pedagogical Content Knowledge can be seen as the teacher's skill to develop suitable methods for delivering a particular concept. In other words, effective teaching methods which help the learner to make sense of the content must be chosen and well planned beforehand. PCK addresses interpreting the curriculum; it covers the main idea of teaching and learning, assessment and reporting. It is imperative that the teacher fully understands the link that exists between the curriculum and pedagogy. Furthermore, it identifies which teaching strategies foster meaningful understanding and address misconceptions and learners' challenges experienced during learning (Ndongfack, 2015). The researcher further mentions that this component also promotes the identification of connections among different content-based ideas. PCK acknowledges prior knowledge which learners have before they are taught a new concept and such knowledge becomes the foundation of new concepts being built in the learners' minds. If they have any misconception about the subject or content, corrections are then made guiding them to build their own knowledge (Luik et al., 2018).

PCK also considers the diverse interests and abilities of learners in the classroom as the teacher organises particular topics. In chapter two, the researcher discussed how learners learn differently and it is the duty of the teacher to make sure that each learner grasps content

that is being taught. This simply means the teacher uses a variety of teaching methods to reach out to the learner, even with technology integration the teacher is not accustomed to one way of teaching with the tools but is creative enough to cater for all learners. Cox and Graham (2009) are also of the idea that PCK includes the understanding of the topic-specific representations in each discipline and how they might be used as part of the teaching activities to promote student learning.

Mathematical content areas are related and each of the areas contributes towards the acquisition of specific skills (DBE, 2011) hence the need for using a variety of innovative teaching methods to assist the learner to understand concepts. Niess et al. (2009) believe that technology is essential in teaching and learning mathematics as it influences concepts being taught and enhances student learning. Mathematics teachers must strive to use different teaching methods in delivering mathematical concepts. In my view, knowledgeable teachers are confident and enjoy sharing knowledge with learners.

### 3.3.6 Exploring teachers' technological content knowledge

Technological Content Knowledge is one of the seven components of the TPACK framework which plays a vital role in the teaching of content with technology. Ondes and Ciltas (2018) stated that education has been affected by the technology advancement, like other disciplines such as engineering, medicine, trade, science and agriculture. Technology has become familiar and most schools in developed and developing countries are geared towards its use. Today's classrooms and school environments have technology available for students to learn better and gain knowledge and skills needed for the future. Accordingly, for mathematics lessons, computerized physical models (manipulatives) are being used to help students to make sense of mathematical concepts or problems. This is done through exploring multiple representations and dynamic geometry software for visualization. Therefore, teachers who are active in the instruction process are expected to have technological content knowledge related to their own fields besides technology knowledge. Knowledge of technology on its own cannot benefit the learner, but it is the starting point for every teacher.

Luik et al. (2018) agree with other researchers in that TCK involves possession of knowledge of subject matter integrated using technology. Innovative teaching methods fully support the idea of technology use in the classroom as it makes concepts more understandable. Teachers with technology content knowledge can select a specific teaching

strategy, as well as the most appropriate technology tool to teach curriculum content effectively (Draper, 2010). It is imperative that a teacher understands the way technology and content influence each other. The choice of technologies may afford or constrain the type of content that can be taught, Archambault and Barnett (2010) hence must be chosen with great care.

Gumbo (2018) acknowledges that the teachers' knowledge on how technology can create new presentations for a specific content impacts how a learner understands that concept. Nowadays teachers are advised to make use of old and emerging technologies in order to improve the way they deliver content to the learners for better understanding (Graham et al., 2009). It is essential that teachers master more than the subject matter and it is recommended that they manipulate and represent data in new meaningful ways.

### 3.3.7 Exploring teachers' technological pedagogical knowledge

Teaching with technology has been a concern for the new generation and features frequently in research however good teaching is not simply adding technology to the existing teaching and content domain (Archambault & Barnett, 2010). Technological Pedagogical Knowledge is an understanding that goes beyond all three main components; content, pedagogy and technology. This knowledge links pedagogy and technology content. Mishra and Koehler (2006) agree that it is an understanding that emerges from interactions among the three components of knowledge. Various technologies can be used in the teaching of mathematics. Gumbo (2018) believes that if teachers fully understand different methods of using these emergent tools then the ways of teaching would also change. Ondes and Ciltas (2018) agree that when a teacher has technological pedagogical knowledge, learning may shift from teacher-controlled lectures to collaborative active workshops. Learners are given an opportunity to play and apply situations into more realistic scenarios. Learners enjoy learning through play however the focus must not be on the game but on the concept being taught. In the Intermediate Phase mathematics classrooms if the teacher has knowledge of different mathematical apps then these can be used to teach concepts, considering the best method that can be used to deliver the lesson. Koehler et al. (2008) reiterate that TPK is an understanding of how teaching and learning can change when technologies are used in particular ways. There is also a need to understand the contexts within which they function bearing in mind that content, pedagogy and technology knowledge interact with one another to produce effective teaching and learning.

Mishra and Koehler (2006) further state that TPK is also related to other managerial tasks in the classroom such as assessment of learners, keeping of records and preparation of lesson plans. Graham et al. (2009) point out that TPK is an extension of general pedagogical knowledge. Teachers with this kind of knowledge understand the impact that technology has on general pedagogical practises that are not specific content related, for example a teacher knows how to manage learning in the classroom with each student using an iPad despite his/her different levels. Elliot (year unknown) supports the idea as he mentions that teachers can use technology to improve communication with learners, to motivate learners, to improve representation of information to learners, actively engage students and help in student assessments.

Nelson et al. (2009) believe that teachers who exhibit best practices with technology are characterised by the creative, flexible and adaptive ways in which they navigate content. With regard to Technological Pedagogical Knowledge an open minded and creative teacher who is a life-long learner is required. As technology and teaching methods are constantly in a state of growth and reinvention, there is need for on-going professional development. Technology use should not merely be for its own sake but for the sake of advancing student learning. Stoilescu (2015) noted that integrating technology is not about technology but primarily about content and effective instructional practices. He further stated that its' integration must not be defined by the amount or type of technology being used but rather by how and why it is used. Stoilescu (2015) argued that in mathematics classrooms teachers are expected to give guidance to students as technology gives additional support that might help them to build their knowledge and understanding of mathematics. Teachers must have the ability to modify the learning strategies based on the applied technology.

### 3.3.8 Exploring teachers' technological pedagogical content knowledge

Technological Pedagogical Content Knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area (Koehler et al., 2008). It also entails understanding complex ways in which these components of knowledge interact with one another. It is important to note that these bodies of knowledge are not isolated, however teaching with technology needs a shift in existing knowledge of pedagogy and content. Mishra and Koehler (2009, p. 3) further clarify that, "good teaching with technology, therefore *cannot* be achieved by simply adding a new piece of technology upon

existing structures but rather requires teachers to develop sensitivity and understanding to the dynamic relationship between all the three components".

Koehler et al. (2008) believe that for teachers to use the TPACK framework effectively, they should welcome the idea that concepts from the content being taught can be represented using technology and pedagogical techniques can communicate content in different ways. TPACK considers the different types of knowledge currently needed in the teaching and learning environments. They further argue that teachers need not be familiar with the entire TPACK framework in order to benefit from it, however understanding that instructional practices are best shaped by content-driven, pedagogically-sound, and technologically-forward thinking knowledge is key. It is also vital to consider that students come into the classroom with prior educational experiences and exposure to technology hence the need to plan effectively catering for needs of different students.

## 3.4 Exploring the relationship between technological pedagogical content knowledge and constructivism

Many studies state that expert teachers have long understood that engaged learners develop a deeper understanding and relationship with content. Learning is meaningful when students co-create and develop their own knowledge. Beck and Kosnik (2006) suggest that students take ownership of their learning when they are provided with opportunities to interact with content to make connections and form new meanings. Constructing knowledge is relevant to students' lives when teachers facilitate learning through skilled pedagogy. Students are naturally motivated through effective pedagogical and technological use.

Based on constructivism, Vygotsky (1896 -1934) developed the Social Learning theory. He certified that students learn effectively in social groups and they make meaning out of their own past experiences. Vygotsky was against learning through memorisation and repetition of concepts repeatedly. He stressed that real learning is not based on what the instructor says even if it is frequently repeated. This is supported by (Beck & Kosnik, 2006) who believe that learners rather construct and build information inside their minds, based on their experiences and prior knowledge.

Vygotsky (1978) believed that each learner has his/her own method of learning and own way of understanding experiences to build knowledge which affects learning. He stressed that learning may take place in both formal and informal environments and in a direct or

indirect manner (Fu, 2013). In such environments, learners can be guided in how to solve a problem by the teacher and later attempt performing challenging tasks on their own. Vygotsky suggested that most learning happens in the Zone of Proximal Development (ZDP), which is the distance between what a learner can do with assistance and what he/she can do without assistance (Vygotsky, 1978). Constructivism accommodates best the change that occurs in educational settings. Integration of technology is believed to positively impact learning as it allows for social groups and caters for learners with different learning styles and needs. Integrating technology may be done in a formal or informal way, for example, learners play mathematics games on computers while mastering mathematical concepts.

Dilworth et al. (2012) argues that in a constructivist–learning environment, technology plays an acknowledged and purposeful role in daily activities. In a constructivist classroom the ideal environment is that of shared responsibility between the teacher and the learner. Learners are believed to be capable of taking charge of their own learning as long as the teacher guides their thinking. Constructivists are against the view that knowledge is transmitted from the knowledgeable teacher to the clueless learners. Today's education systems require interactive mathematics classroom environments where learners' viewpoints are considered. Education reformation acknowledges a learner as an active participant and not a beaker waiting to be filled with knowledge (Koc, 2005). In traditional classrooms this is unheard of. The researcher believes that interactive and relaxed environments where technology is integrated may promote positive attitudes towards mathematics as a subject.

## 3.5 Exploring the relationship between technological pedagogical content knowledge and mathematics education

The effective use of technology in mathematics classrooms has been subject to much debate by mathematics educators (Calder, 2010). Several educators are believed to be using technology to replace or supplement teaching resources Muir, Callingham, and Beswick (2016) much focus on *what* technologies are used rather than *how* they could be used to enhance teaching and learning. It is crucial that teachers be aware of technologies which offer useful representations in mathematics classrooms, taking into consideration older and newer technology- based tools available. Muir et al. (2016) believe that in order to teach mathematics effectively and in depth, there is a need to master adequate mathematics content. Furthermore, the teacher must be pedagogically able to help students and systematically build an understanding of mathematics. In addition, teachers should be able

to understand and use technology instruction effectively. Mishra and Koehler (2006) reiterate that TPACK in mathematics classrooms goes beyond the knowledge of learning about a technological tool and its operation, to the knowledge of how technology -based tools are operated in order to improve mathematics teaching and learning.

It is believed that technology has hugely impacted on the development of new and existing mathematical concepts. It has influenced content development and exploration in areas such as algebra, geometry and probability, just to mention a few (Ondes & Ciltas, 2018). Technology can also be used to foster mathematical thinking and reasoning skills and allows students to develop a deeper understanding of mathematical concepts. Furthermore, technology integration allows learners to use higher level approaches to solve mathematical problems that would not be possible without technology. The researcher agrees with Mishra and Koehler (2006) who believe that teachers should be competent in TPACK skills in order to adequately integrate technologies into their mathematics lessons.

## 3.6 Exploring the technological pedagogical content knowledge developmental model

Teacher development programs must guarantee that mathematics teachers are afforded opportunities to gain knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics. Walsh (2017) warns that use of technology is not a guarantee of better teaching or learning. Therefore, careful consideration in choosing technology-based tools for integration in mathematics classrooms must be emphasised. Teachers should be mindful to choose appropriate tools for integration as they plan for mathematics lessons.

Niess et al. (2009) argue that technology integration influences teaching and learning of mathematical concepts and has the potential to enhance students' learning. It is stated that in the 21$^{st}$ century, teachers should learn how to create positive environments which promote collaborative problem-solving and incorporate technology in meaningful ways (National Council of Teachers Mathematics, 2007). This will eventually assist them to support student thinking and invite intellectual exploration.

Based on Rogers's (1995) model, Niess et al. (2009) developed the TPACK developmental model. Rogers's (1995) model addressed diffusion of innovations in a particular society. Initially, he created a sequential process explaining how a person decides to adopt or reject innovation. Niess et al. (2009) reframed and aligned this model in terms of mathematics

teachers' ability to integrate a particular technology that they had not yet integrated. It is imperative to note that this process is still work in progress as new technologies are being introduced into mathematics classrooms and more research is still underway.

## 3.7 Developing teachers' competencies in using technological pedagogical content knowledge in mathematics classrooms

Numerous technologies have penetrated various facets of life throughout the world. Some researchers believe that teachers have not yet fully utilized technology in the teaching and learning process (Ramorola, 2013). Some argue that most teachers in the developed countries like Australia and the United States have been trained on how to integrate technologies into teaching and learning and have a fair understanding of the TPACK model. In most developing and underdeveloped countries (mostly African countries), the TPACK framework may not yet be fully understood by many teachers simply because of lack of technology in the schools (Koh, 2015; Mdlongwa, 2012). Some researchers believe that teachers' inability to handle the technology tools has been largely blamed on inadequate or lack of professional development of teachers (Fu, 2011; Karsenti et al., 2012). If TPACK has been widely and successfully used in other countries the question is, do South African teachers, especially mathematics teachers understand what the framework entails?

According to research, most pre and in-service teachers in South Africa are believed to be lacking in terms of technology integration. There is a need for developing teachers' competencies in using the TPACK model. These can include micro–teaching with assistance from mentors, collaboration in lesson designing, peer evaluation, support systems focusing on subject specifics, and better communication with curriculum developers.

## 3.8 Critics of the Technological Pedagogical Content Knowledge framework

Some researchers have pointed that the TPACK framework is associated with several challenges. One of the researchers, Stoilescu (2015) believes that the framework inherits most of the insignificant irregularities that Pedagogical Content Knowledge has. He argues that it is similar to PCK in the sense that it lacks clarity in determining with accuracy, the level of knowledge that is displayed by the teachers' technology integration in each component. The framework does not consider the attitudes and opinions of teachers. Furthermore, paradigms of teaching and social and cultural backgrounds of teachers are not considered. Lehtinen, Nieminen, and Viiri (2016) also believe that the framework does not offer a prescriptive formula for the best way to teach with technology as it is difficult to

separate the domains from each other. It must also be considered that developing TPACK capabilities is not a one-time activity. It is a process where teachers continuously must evolve new ways of teaching. This may require constant development and constant collaboration with peers in order to find reliable and tested ways of using the technology tool. Despite this, several researchers still maintain that TPACK framework does not necessarily mean that new technologies must be introduced instead it provides a framework for teachers to organize their knowledge of technology, content and pedagogy for effective use of available technology in a given teaching and learning context.

## 3.9 The development process of integrating technologies into Mathematics

The emergence of new technologies demands that teachers rethink its acceptance especially in mathematics teaching and learning. It also necessitates rethinking content and pedagogies. Niess et al. (2009) observed teachers going through the five stages of the development process which they described as follows:

**Table 3: The five-stage development process**

***Source: Niess et al., 2009 p. 9***

| The five stages of the development process |
|---|
| 1. **Recognising (knowledge)** - *where teachers can use the technology and recognize the alignment of the technology with mathematics content yet do not integrate the technology in teaching and learning of mathematics.* |
| 2. **Accepting (persuasion)** -*where teachers form a favourable or unfavourable attitude toward teaching and learning mathematics with an appropriate technology.* |
| 3. **Adapting (decision)** - *where teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with an appropriate technology.* |
| 4. **Exploring (implementation)** - *where teachers actively integrate teaching and learning of mathematics with an appropriate technology.* |
| 5. **Advancing (confirmation)** - *where teachers evaluate the results of the decision to integrate teaching and learning mathematics with an appropriate technology.* |

The five stages are discussed in detail by Niess and other researchers are;

**Stage 1 - Recognising**

With the introduction of technologies in schools, researchers believe that there is a process in which teachers gain mathematics TPACK knowledge. Initially, Rogers explained an innovation decision process describing the sequence of how one decides to adopt or reject innovation. This idea was further developed by Niess, Sadri and Lee in 2007. Niess et al. (2009) believe that classroom practitioners undergo five stages of development namely recognising, accepting, adapting, exploring and advancing which lead them to technology adoption. These researchers reformed the idea in terms of teachers learning how to integrate tools that have not yet been integrated into teaching mathematics. The process shows how teachers develop mathematics TPACK knowledge through the five stages.

During the first stage the teacher can use the technology tools however he/she strongly retains core beliefs about how students learn mathematics. In most cases this may be through memorisation of rules, formulas, algorithms and following certain procedures without necessarily using technology. Such beliefs hinder the teacher from exploring and experimenting with technology-based tools. The teacher may resist changes brought by the innovative tools even though there is recognition that mathematical concepts can be displayed with technology. Most lessons are delivered in lecture format followed by repetition in order to consolidate ideas. At this stage the teacher views most technology activities as focused on learning about technology within a mathematics context, rather than teaching mathematics concepts with technology.

**Stage 2 - Accepting**

This is the persuasion stage where attitudes (favourable or unfavourable) related to the use of technology-based tools in teaching mathematics are formed. The teacher accepts that some technologies can be useful for teaching and learning mathematics and desires to use them to teach mathematics. Technology- based tools are only seen as appropriate teaching tools rather than learning tools. This simply means that technology-based tools are viewed as effective tools only when they are utilised by the teacher and not necessarily by learners to form concepts. Integrating technology-based tools is believed to take away important time for teaching mathematics. Furthermore, teachers usually raise concerns about learners' attention being diverted to the technology tools themselves instead of the concept being taught. Even though some technologies are useful, teachers may find it difficult to identify topics which may be aligned to these technology- based tools.

**Stage 3 - Adapting**

During the third stage, the teacher is aware of some of the benefits of incorporating technology-based tools with regard to teaching and learning mathematics. There is belief that the tool is used primarily as a means of implementing new teaching strategies and does not necessarily enhance the teaching of mathematics. Technology-based tools are known to be enhancing mathematics ideas that learners already possessed prior to the use of the tools. The teacher may show the desire to explore and experiment using the tools for the purposes of both teaching and learning. Failure to implement technology integration may sometimes be restricted by challenges (for example; classroom management, fewer resources, technology glitches), which may arise during technology integration. At this stage the teacher may question how students think when technology-based tools are used for teaching and learning mathematics. Teachers at this stage can decide to adopt or reject incorporating appropriate technology-based tools.

**Stage 4 – Exploring**

In the fourth stage, teachers are excited about integrating the tools into mathematics lessons and they explore them in different ways. They accept that technology -based tools can be effectively used for teaching and learning specific topics in the syllabus. Planning, implementation and reflecting on teaching and learning is done using technology tools however there is a concern for guiding learners to understand mathematics concepts using technology-based tools. At this stage teachers are willing to explore various instructional strategies and are willing to learn and expand on new ideas for integrating technology in the classroom. Even though challenges for teaching mathematics with technology-based tools are recognised, the teacher strives to use other strategies and ideas which may minimize the impact of these challenges. The teacher presents technology enhanced activities which fully engage learners as he/she guides them. Most lessons are a success as the teacher puts maximum effort with tools that he / she has.

**Stage 5 – Advancing**

The last stage of the development process is whereby teachers have accepted the integration of the tools and are actively exploring them in a consistent manner. All available technological resources are utilized in a maximum way and teachers explore ideas for

teaching and learning mathematics with different technologies. Tools engage learners in a variety of high-level thinking activities like problem-solving and mathematics projects. Their motivation to use the tools is reflected in the lessons that are well planned and prepared for in advance. Plans to resolve challenges brought by technology-based tools during teaching time are planned for in advance. At this stage teachers can explore and experiment different strategies that accurately translate concepts in a creative way. Teachers in this stage firmly believe that integrating technology tools into mathematics lessons helps students to understand mathematical concepts in a better way.

Teachers require several competencies to build innovative teaching and learning environments designed to accommodate social constructivist views of learning. It is through various interactions that learners internalise knowledge. Teacher competencies, which include knowledge of technology integration, knowledge of different teaching methods and content knowledge, are necessary skills needed for the 21st century teachers hence cannot be ignored in the learning institutions. Basic understanding of different types of knowledge needed for integrating technologies can assist teachers assisting learners in grasping mathematical concepts. The TPACK framework also give guidance as to how teachers can incorporate technology in their classrooms in a successful manner.

## 3.10 Conclusion

It seems technology education has been and will continue to be part of education of all learners, with a view to them becoming employable citizens who can contribute meaningfully to society (Nokwali et al., 2015). Although technology integration reforms teaching in a classroom, its implementation may not be easy for all teachers (Koc, 2005). He further points out that its use as a learning tool can make a remarkable difference in learner achievement, fostering self- directed learning and higher order thinking. The TPACK framework helps to improve understanding of technology integration. It is one of the models which is a powerful reminder of the importance of being both innovative and mindful in the use of technologies. It is worth considering when teaching with technology. Walsh (2017) says it is also vital to consider contexts in which the model can be used or applied. A teacher can be knowledgeable in content, pedagogy and use of technology tools however, the availability of technology, school policies and the curriculum being used may be a threat to the use of the model. TPACK context affects both teachers' conceptualisation and enactment (Swallow & Olofson, 2017). Researchers (Smith et al., 2015; Honey, 2017) have pointed

out that teachers' beliefs and attitudes about technology integration in mathematics lessons impacts the use of the TPACK framework by different teachers. Mathematics teachers who are committed to teaching the subject effectively need to develop a full understanding of the TPACK framework and have positive attitudes towards innovative ways of teaching.

# Chapter Four

# Research Methodology

## 4.1 Introduction

The preceding chapter outlined a literature review the concept of integrating technology into teaching and learning of mathematics. The Technological Pedagogical Content Knowledge (TPACK) framework discussed the relationship between content, pedagogy and technology.

This chapter discusses methodologies used to explore the study and describes the data collection process. The researcher seeks to explain the sampling process used for the study and give reasons for the sampling procedure. Methods of data collection are described briefly, and measures taken to ensure reliability and validity are included. The researcher concludes with explaining the ethical issues and limitations during the study. The study is grounded on a qualitative method of data collection within an interpretive paradigm.

## 4.2 Research Questions

The study intended to explore the integration of technology-based tools in the Intermediate Phase mathematics classrooms. The researcher believes that the study will positively contribute to the 21$^{st}$ century classrooms where technology has hugely impacted teaching and learning. This study is aimed at specifically bringing about effective teaching and learning of mathematics in the Intermediate Phase classrooms.

## 4.3 Research Paradigm

Creswell (2007, p. 47) describe a research paradigm as, "a set of assumptions or beliefs about fundamental aspects of reality which give rise to a particular world view." In simple terms, paradigms model what we think about the world even if we cannot prove them. These researchers further explain that paradigms address assumptions of conclusions on the nature of reality which is called ontology. It also addresses relationships between what is known and people who know it (epistemology). Maxwell (2005) concurs that it is a set of very general philosophical assumptions about the nature on the world and how we can understand it. These are assumptions common among researchers who work in a specific field. This study is framed within the interpretivist paradigm.

Interpretivists' base their assumption on that, origin of meaning is the human mind and human behaviour is affected by knowledge of the social world which affects human behaviour. This paradigm offers insight into the way in which a group of people make sense of their situation or of the world in which they live (Creswell, 2007) . Singleton and Straits (2009) further elaborate that interpretivists subscribe to the view that there is no single route or method to knowledge. Interpretivism is a theory of meaning and understanding, beginning with the assumptions and then accessing reality through social constructions and shared meanings. Wilson and Wilson (2009) highlight that adoption of a paradigm is principled as it relates to the nature of what is being researched. The selection of a paradigm determines the choice of the appropriate research strategy (methodology) and in turn methodology drives the techniques for data collection. MacMillan and Schumacher (2006, p. 12) argue that qualitative research is also based on constructionism, which assumes multiple realities socially constructed through individual and collective perceptions of the same situation.

This research study attempts to make sense of participants' views based on their experiences on integrating technology – based tools into mathematics classrooms. The link that exists between an interpretive paradigm and qualitative methodology cannot be ignored as it subscribes to the idea of holistic understanding of a particular event or situation. This study attempts to understand the integration of technology-based tools in mathematics particularly in the Intermediate Phase. The researcher aims to understand this phenomenon through the eyes of the participants, who in this case are Grades 4 to 6 mathematics teachers.

Wisker (2009) believes that researchers cannot find out or fix reality, but can certainly interpret it, having sought out views from participants' worldview and context. This ensures

that the research itself is thoroughly done and internally valued. Conclusions are then made with the awareness that although they might address certain questions, populations and contexts, results cannot be generalised to other contexts. On that note, results for this study will not be generalised as only a small population was used.

## 4.4 Research design and methodology

Putman and Rock (2018) describe research methodology as a systematic way of solving the research problem, encompassing the research methods, the research design and further incorporating the logic behind selection of different methods used to conduct the research.

On the other hand, (Mills, 2011) describe the research design as the plan to collect the evidence necessary to reach the conclusions of the study. Welman, Huysamen, Kruger, and Mitchell (2005, p. 52) record that research design is "the plan according to which we obtain research participants and collect information from them." The main function of the research design is to articulate the process that will be used to ensure efficiency as well as maximise reliability and validity of the process of collecting data, and careful planning of the research design.

According to Maree (2007), a research strategy moves from philosophical assumptions to specifying selection of respondents, specifying data gathering techniques to be used and the data analysis to be done. The research problem and researcher's assumption leads to the choice of the research design and incorporates the logic behind the selection of the methods for the research. As mentioned above, this study considers a qualitative approach to be appropriate for the study as it provides more flexibility and gives a rich description of a case.

Merriam (2009) argues that in a qualitative research various considerations must be considered. These may include seeking to understand situations in their differences as part of a particular context and the interactions thereof. Furthermore, researchers must understand the nature of that setting, what it means for participants to be in that setting and what their lives are like. The researcher further points out that it is also vital to understand how the world looks in that setting. This leads to an extensive analysis in order to get a deeper understanding of the situation. The behaviour is observed as it occurs, and the researcher attempts to answer research questions by acquiring an in-depth narrative understanding directly from teachers. The study also attempts to focus on participants' understanding taking into consideration that there may be multiple perspectives from

different teachers integrating technology. No manipulation or control of behaviour or setting was done and data was observed and collected in the classrooms during mathematics lessons.

A number of studies point out some of the pitfalls of qualitative approach. Researchers are warned to be cautious as the evidence or data collected may be subject to the biases of the people involved. Participants may have biases about either the researcher or the topic and may sometimes be reluctant to disclose personal feelings or ideas. Researchers themselves are cautioned about having preconceived ideas about the evidence they are likely to find in their investigation.

## 4.5 Sampling

Sampling can be done through two major techniques, namely - probability and non-probability sampling. In probability sampling, subjects are selected from a larger population in such a way that the probability of selecting each member of the population is known and efficiently provides an almost true presentation of a population from a smaller group of subjects (Maxwell, 2005). On the other hand, non-probability sampling does not include any type of random selection from a population, instead the researcher chooses subjects who happen to be readily available or who may present certain types of qualities (MacMillan & Schumacher, 2006). This study uses purposive non-probability sampling. Intermediate Phase Mathematics teachers at a specific school in Durban, KwaZulu Natal were chosen for this study.

### 4.5.1 Purposive sampling

The sample was drawn from the Intermediate Phase educators who teach mathematics in a primary school. The school was identified to be integrating technology in teaching students in all learning areas. To address the purpose of the research, participants who are well acquainted about the research topic were selected. These were considered as participants who are representative of information rich subjects. The researcher chose this type of sampling because of its ease of administration. It is less costly and not time consuming, with the researcher having the assurance of obtaining the needed information. The challenge was that it was less representative of the identified population. However, some researchers MacMillan and Schumacher (2006) point out that small samples of informant rich cases may be selected without desiring to generalise results. Welman et al. (2005) argue that the challenge with purposive sampling is that different researchers may proceed to obtain samples in different ways. It then becomes difficult to ascertain the extent to which those

samples correctly represent the relevant population. The purposive selection allows the researcher to make specific choices about who to choose on the targeted specific group. The researcher was targeting mathematics teachers who integrate technology into their lessons as this is currently not happening in all schools. The chosen site was convenient and accessible which was advantageous to the researcher who teaches in one of the local schools in a nearby suburb. The researcher will use Sunflower School, as the pseudonym for the participating school.

### 4.5.2 Study Setting

The research site used for this study is an independent day school. The school is inclusive of all races and is situated in one of the suburbs in Durban, in the KwaZulu - Natal province. It has very good infrastructure, which is well equipped with modern facilities. It consists of the Foundation Phase (Grades R-3), the Senior preparatory school (Grades 4 -7) and a High school catering for Grades 8 -12. At the time of research study, the enrolment was above one thousand and the teacher to pupil ratio in each class in the Intermediate Phase ranged from thirteen to twenty learners to one teacher. The school has two to three classes per Grade with each teacher responsible for teaching two or three learning areas. The school prides itself in several specialist teachers for sciences, mathematics and languages from Grades 4-12 Parents enrolling their learners at the participating school are liable for paying school fees. The school also offers a variety of sporting activities with each child given a choice to partake in sporting activities of their preference.

In total there are nine classes in the Intermediate Phase. The researcher identified nine participants who were available during the period of data collection. These participants were found to be willing to have the researcher observe how they incorporate technology-based tools into their mathematics lessons. While the researcher managed to observe five different participants in the Intermediate Phase, other participants were provided with the questionnaire. These included three teachers who were not available for observation but indicated that they were willing to fill in the questionnaires. The researcher spent five weeks observing lessons that were evenly spread by the Head of Department for mathematics. The purpose of the study was explained to each teacher letting them understand that the researcher will fit in and follow his /her schedule.

### 4.5.3 Description of the participants

The researcher made use of pseudonyms for all the participants.

**Table 4: Summary of participants who participated in this research study**

| *Name of participant* | *Gender* | *Age group* | *Teaching experience in Mathematics* | *Trained to use technology* | *Data collected through:* |
|---|---|---|---|---|---|
| Lily | Female | 30-39 | 11-15years | ✓ | Observation |
| Daisy | Female | 50-59 | 16-20years | ✓ | Interview |
| Iris | Female | 40-49 | 16-20years | ✓ | Interview |
| Heather | Female | 30-39 | 10-15years | ✓ | Questionnaire |
| Rose | Female | 40-49 | 16-20years | ✓ | Observation |
| Azalea | Male | 50 -59 | +20years | ✓ | Interview |
| Violet | Female | 60-69 | +20years | ✓ | Questionnaire |
| Orchid | Male | 30-39 | 6-10years | ✓ | Observation |
| Aster | Male | 20-29 | 5-10years | ✓ | Observation |

All the participants have received training in teaching with technology. Occasionally, the school offers them training in upgrading their skills to keep abreast of current technology skills. One of the participants is the Head of Department of mathematics. The participants have been introduced to new mathematics software and they are teaching using the software with ease.

**a) Lily**

Lily is a female teacher who has taught at the school for more than ten years. She teaches English, mathematics and natural sciences to Grades 4 and 5. She is a qualified teacher in her early thirties and holds a Bachelor's Degree in Education with a mathematics specialisation. Lily was willing to assist the researcher with information on how technology-based tools are integrated into mathematics classrooms. She is quite confident in using the interactive whiteboard during her lessons and she involves her learners extensively. She makes her lesson as interesting as possible and believes so much in rewarding learners who have done well. It was a pleasure to observe a young and energetic teacher who seems to be passionate about teaching mathematics.

**b) Rose**

Rose was an accommodating participant who was always of great assistance to the researcher. She has been teaching mathematics for more than fifteen years in the participating school and also at other schools. She has a specialisation in mathematics and holds a Degree in Education. Her approach to teaching mathematical concepts is very interesting as she has something new and interesting to offer to learners to arouse their interest in the beginning and throughout the lesson. She is the Head of Department of mathematics in the Intermediate Phase and was kind enough to show the researcher around the Intermediate Phase classrooms introducing her to other participants. Rose is very observant; during her lessons she attends to individual learners and assists them if they are not coping. She also makes use of teaching aids that she prepares at home although technology caters for that. During her lesson she was able to explain to the researcher how and why she integrates technology-based tools. She also teaches natural sciences.

**c) Orchid**

Orchid is a male teacher who has served the school for more than five years. He teaches mathematics (Grades 4 and 5), social sciences (Grade 6) and English (Grades 4 and 5). He is comfortable in using technology-based tools in teaching all the subjects. He is very innovative and creative when it comes to using the interactive whiteboards. He also shows the learners how to get the best out of their iPads. Mr Orchid is a holder of a Bachelor Degree in Education and has been exposed to other highly technological environments in first world countries, where he taught for a few years before teaching at the participating school.

**d) Daisy**

Daisy holds a teaching degree and is new at the participating school, however she has been in the teaching field for more than fifteen years in other schools. She has also taught outside South Africa where she gained vast knowledge about technology use. She also teaches natural sciences and one language subject to different grades in the Intermediate Phase. She uses technology-based tools with confidence and believes that all learners have the potential to perform well and achieve good results in mathematics. One of her strengths is motivating learners and helping them to develop love for mathematics as a subject. She also has confidence in traditional teaching methods however, she stresses that they must go hand in hand with technology use to assist the learner to understand concepts

**e) Aster**

Aster is an energetic participant who integrates technology-based tools to their full potential in various ways. He holds a teaching degree in primary education and enjoys creating mathematical games which he shares with his colleagues and his learners. He has attended many workshops on teaching using technology tools and he sometimes co-teaches with other mathematics teachers showing them how best they can use the technology-based tools. When teachers are experiencing any glitches, before they could call for the IT specialist he checks and works on it. He has been at the school for more than five years but less than ten years.

**f) Iris**

Iris is one of the oldest teachers in the school. She holds a Diploma in Education, a Bachelor Degree in Education and a Masters' Degree in Education. She has been a teacher at the participating school for many years and at some point, she took early retirement, however the school asked her to return because of her excellent service in teaching mathematics to both Grades 6 and 7 classes. She was not observed integrating technology tools but was interviewed. From her responses one can say that experience and passion for teaching makes her an efficient teacher. She is willing to learn more about technology and says that her learners are good with technology and they assist her when she struggles. Iris taught at other schools before coming to the participating school.

**g) Violet**

Violet is an experienced teacher who integrates technology tools into all her lessons. She is skilled in the use of different technologies and is of great assistance to other colleagues in terms of sharing engaging mathematics activities. She is passionate about teaching mathematics and points out at how fearful she was at first when technology was introduced to the school. With on-going training and team collaboration she is now very confident and willing to share the knowledge she possesses with others. She teaches mathematics and one of the first additional languages at the participating school. Even though she is in favour of use of technology tools into enhancing teaching and learning Violet is still against learners bringing phones to school as she thinks the learners will do silly things with them.

**h) Azalea**

He is one of the long serving members of the staff with a passion for teaching mathematics and has taught in both in primary and high schools. Currently he is the Associate Headmaster of the Intermediate and Senior Phase and leads the mathematics and science department. He is responsible for sourcing new mathematical programs for the phase and is currently working on finalising the introduction of a new mathematics program which he believes will elevate the learners' level of understanding of mathematics. He does not have a class to teach however he assists teachers in delivering quality mathematics lessons. Sometimes he teaches certain topics that teachers struggle with (if ever they need assistance).

### 4.5.4 Description of technology-based tools used in the participating school

Each classroom has a computer, projector and a whiteboard mounted on the wall for the teacher and an interactive white board and a projector mounted. Teachers are stationed in the same classroom while learners move from one class to the other according to the subject on the timetable.

The following tools found in each classroom in the participating school are described by Cole (2006) and Chin (2004) as follows;

**A projector**

A projector is a digital device (usually white) which can be moved around or mounted on the wall. A projector works with a desktop, laptop and a screen. It allows projection of any illustration which becomes interactive to a larger extent. It is a display tool which projects the display from a computer onto a large viewing surface. Data projectors are found in many South Africa classrooms and are used as audio – visual display equipment and can be used

to show videos or PowerPoint slides. PowerPoint slides have an advantage of having interactive features compared to traditional images which are static.

**An iPad**

Each learner carries his own iPad for use in the classroom. This is an extension of the whiteboards, which have been used in the school for more than five years. The iPad is purchased by each parent when the child is enrolled at the school. It is the responsibility of the learner and the parent to make sure that their child has an iPad working in good condition. These iPads are synchronised with the school server and Wifi in the school allows for the installation of different apps. The iPad has several educational and creative applications which enable teachers to create engaging learning experiences both in the classroom, during lessons and at home. Textbooks are also downloaded in each iPad which assist the learner to work from home with ease. All learners are empowered to use the iPads right from Grade 4.

**Educational Whiteboards**

Educational whiteboards are great tools for displaying information. Some whiteboards are interactive, and some are not and the participating school has both interactive and non-interactive boards. These can display a wide range of media, beginning from texts, videos, animations and websites. It also allows teachers to add extra information in the textbook, highlight key words or passages and add video clips. Teachers and learners can operate the board by using their fingers and are fun to use. There are different types of interactive whiteboards on the market which allow teachers to create customised resources and adapt them to the needs of their classes

**The internet**

The internet is a facility which allows one to access information and serves as a library which stores and provides raw information through different search engines like Google. For one to access this information airtime, data or Wifi is needed. The internet enables learners to widen their knowledge on a specific subject however they need guidance on surfing the web in a productive way. Learners use the internet during mathematics lesson to check the meaning of new vocabulary and to check different concepts.

## 4.6 Data collection techniques

Qualitative collection methods make it possible for the researcher to study the behaviour as it occurs naturally (MacMillan & Schumacher, 2006). The researcher must plan on the choice of methods to be used in the data collection process. In this research study, three data collection methods namely lesson observations, questionnaires and interviews were used. Maxwell (2005) argues that selection of methods does not only depend on the research questions but also on the research situation and on what will effectively work in that particular circumstance to elicit the data needed. It allows researchers to gain a wider and more secure insight into the issues that are being investigated. He further advises that using a variety of sources and methods reduces the risk of conclusions reflecting only the systematic biases or limitations of a certain source or method. Merriam (2009) argues that triangulation is a process of adopting multiple sources of data by means of comparing and cross checking the collected data through observations and interviews from people with different perspectives. Through triangulation, cross validation among data sources, valuable and reliable data collection is made possible (MacMillan & Schumacher, 2006). Triangulation assists the researcher to ensure a more accurate account of the phenomena; it also helps to confirm interpretation through comparing of different data sources (Wisker, 2009) .

## 4.7 The pilot study

Before the actual data collection process was done, the researcher carried out a pilot study. Researchers, Kruger, Mitchell, and Welman (2005) argue that a pilot study is a typical fashion of how the actual study of a specific nature will be conducted. This was undertaken to examine the strength and appropriateness of the instruments used for the research purpose (interview schedule, the questionnaire and the observation schedule). Participants with similar characteristics to those that could be used in the study were identified during the cluster meeting. It was vital for the researcher to check if the data collection instruments elicited the desired data. Two teachers from different schools that integrate technology in mathematics were requested to take part in the pilot study. The researcher administered the pilot instrument in the same way it would be administered during the main study and the participants were given a week to write critical comments about individual items on each research instrument.

Following the pilot study, certain questions were rephrased, ensuring that questions were made clear and some were eliminated.

## 4.8 Observations

MacMillan and Schumacher (2006, p. 347) describe participant observation as "a data collection method which enables the researcher to obtain peoples' perceptions of events and processes expressed in their actions and expressed as feelings, thoughts and beliefs."

Before the researcher conducted the observation process, permission was obtained from the Principal of the site and access to conduct research at the school was given. The Head of the Mathematics Department drew an observation timetable for mathematics lessons that were going to be observed (Grades 4 -6). This was done in consultation with all the participants and the final timetable was e-mailed to the researcher. Thereafter the researcher was then introduced to individual participants and the Head of Department assisted the researcher to familiarize with the Intermediate Phase classrooms. The researcher met each participant prior to the class observations to discuss what the research was all about and to get a picture of how she will work with each participant. The reason for the research study was shared with all teachers involved.

The researcher communicated to each member that their identity will be not be disclosed in the future when data analysis is being made, but instead the researcher will use pseudonyms to refer to individual teachers.

As the researcher observed the integration of technology-based tools in mathematics classrooms she made some field notes and took some pictures. The observation notes were made while the class activities were taking place as suggested by Welman et al. (2005). This is done to preserve observations as much as possible. The researcher took pictures and recorded information on an observation schedule. An observation tool had been prepared and the researcher shared it with the participants. The researcher observed the following:

i. Duration of the lesson.
ii. Concept covered.
iii. Teacher to pupil interaction/ Pupil to pupil interaction.

iv. Classroom arrangement.
v. The tools used to teach the concept and how they were being used by participants.
vi. Other tools / teaching aids used to teach the concept.
vii. Method of teaching used by the participant.

Wilson and Wilson (2009) warn that classrooms are very complex social settings and there are many things happening at once hence the need to plan carefully for the observation process. He further warns not to try to record everything as you might end up with a very superficial analysis or limit your focus too much as there is danger that you only see what you want to see. The researcher took note of non-verbal behaviour of the respondents during the interviews.

In each Grade there were two participants observed. The researcher observed six participants in total, all of them being mathematics teachers. For one to be a teacher in the Intermediate Phase one needs to hold a Bachelor Degree in the Intermediate Phase. Four of the participants have a specialisation in mathematics. Each participant was observed for five weeks using an unstructured observation schedule (Appendix G). The researcher captured some field notes which will be used for future reference. Researchers, Macmillan and Schumacher (2006) advise that one should record detailed descriptive fields that are not vague or judgemental. The researcher recorded events as they were happening and tried not to be judgemental in any way. Photographs of the technology-based tools being used were also taken and the researcher avoided taking pictures of participants and learners in classrooms as she was not given consent to do so. Through this process the researcher was able to observe and capture specific events therefore gathering new information.

## 4.9 Questionnaires

Collecting data using the questionnaire was also chosen by the researcher, as it is an appropriate method which can be used to collect descriptive data. Maxwell (2005) views a questionnaire as a list of closed and open ended questions, written for an interview to be answered either face to face or as a written response. A questionnaire is simply a list of written questions which must be answered by participants however, Welman et al. (2005) state that questions should only be a part of the questionnaire if they will aid in answering the research questions.

The researcher gave participants the questionnaire (Appendix F) to fill in right from the onset of the data collection process. They were asked to return the questionnaire in one

weeks' time. The questionnaire was used to determine technology-based tools integrated into mathematics classrooms, why they are being used and how they are being used. The questionnaire was composed of Section A which mostly contained a set of personal questions and Section B with open-ended questions which sought more information on integration of technology-based tools into mathematics lessons. The set of closed questions sought to collect information which included gender, years of experience, grade/s being taught, subject/s being taught and any type of specialisation. This set of questions offered respondents a variety of answers from which to select. As suggested by Welman et al. (2005) the categories reflected in the closed questions were mutually exhaustive and exclusive in order to provide for every possible response.

The last part of the questionnaire included open- ended questions in which the interviewer asked questions without any prompting with regards to the range of answers expected. The researcher provided space for the respondent to write his/ her opinion or answers and the responses were noted verbatim. One advantage of such questions is that the researcher cannot have an influence on the answers, and they are a rich source of data which may not be addressed by closed questions. The first set of open-ended questions sought to collect information about different types of technology tools used in the classrooms, how these tools are used in mathematics classrooms and the respondents had to write reasons for using these tools. Advantages and disadvantages for using these tools in mathematics lessons were also included in the questionnaire.

The researcher ensured that the questionnaire was neither too long to discourage participants to fill it in, nor too short to ensure that the important data was included. The questionnaire was also designed in a way that did not suggest responses as this is warned against by Cohen, Manion, Morrison, and Morrison (2007). Researchers, Welman et al. (2005) warn against drawing ambiguous questions with more than one meaning, leading questions that suggest certain responses and loaded questions. The researcher tried formulating concise and brief questions. Before the questions were finalised, they were given to a colleague, a mathematics teacher to check if the questions were clear and responded to each critical research question.

The researcher delivered the questionnaires in person and asked participants to seek clarification if they lacked understanding. The participants were requested to respond according to the best of their knowledge and were assured that the responses will be solely used for the purpose of this research work. Participants were made aware of their right to

privacy, hence, there was no need for them to write their names on the questionnaires. For the purposes of data analysis, the researcher wrote pseudonyms given to participants on each questionnaire.

## 4.10 Interviews

Different kinds of interviews are used in data collection. These may include structured, semi-structured and unstructured interviews. All three types of interviews may be used in qualitative contexts however, great care must be taken when choosing the type of interview to be used as each type suits different contexts. Wisker (2009, p. 130) captures that, "interviews enable face to face discussion with human subjects and the researcher can explore people's thoughts and feelings when you meet with them, in context, and capture this rich information." These face to face interviews give the researcher an opportunity to take note of non-verbal as well as verbal behaviour (MacMillan & Schumacher, 2006). They also allow the researcher to motivate the interviewees to generate rich data. In this study, two participants availed themselves for the interview however a focus group interview which had been initially planned for could not be implemented. Both interviews were semi-structured, with the researcher having a set of questions to be covered and space for exploring ideas. The researcher focused on the first-hand experiences of participants as they daily use technology-based tool. Participants tried to reveal their experiences to the researcher. The participants were available for the interviews at different times and the researcher finally had to interview participants individually whenever they availed themselves. Interviewing participants was not an easy task as participants indicated that they were busy. Both participants were interviewed at the school but on separate dates.

When conducting an interview, Welman et al. (2005) point out that the researcher must introduce the study, its purpose and orient the participants to what the questions are. The researcher elucidated the objective of the study, which is finding the technology-based tools that are being integrated into mathematics classrooms and how these tools were integrated. Participants were asked to co-operate and the researcher highlighted how the study could help other colleagues in the teaching profession especially mathematics teachers. The questions should not be asked in a leading or directed manner to avoid having the respondent providing to answers that he or she thinks the interviewer wants to hear. Researchers advise that language used for formulating questions must be simple and understandable. Before conducting the interview with the participants the researcher tried to do one with colleagues as advised by Wisker (2009) and necessary corrections were made. Questions were

rearranged and ordered in a developmental manner. Ambiguous questions were removed from the instrument.

During the interview, the researcher tried to manage time well, keeping in mind that participants have other commitments, no jargon was used, and the questions were phrased clearly. The researcher also tried to keep the conversation as natural as possible and tried to get clarification through probing. Cohen et al. (2007) agrees that interviews allow researchers to get clarification on vague responses through probing. During the interview the researcher probed participants for clarity particularly on responses that were not clear. Notes about everything that was said were recorded in detail to be used for further analysis.

As mentioned before, participants indicated that they were not comfortable with recording the conversation hence the researcher made use of detailed field notes. Welman et al. (2005) describe field notes as observations that are made by the interviewer or the researcher. The interviews aided the researcher in exploring the participants' ideas and to identify their attitudes and feelings about the study.

## 4.11 Ethics

Merriam (2009) maintains that the validity and reliability of a study depends upon the ethics of the investigator to a large extent. The researcher tried her best to adhere to the ethical provisions to protect the identity of participants throughout the study. According to Marshall and Rossman (2011, p. 39) the research must be "well thought out and should be carried out with ethical mindfulness". If this is followed properly, sensitive aspects emanating from interactions between gatekeepers, participants and the researcher may be curbed. Creswell (2007) points that trustworthiness in a qualitative design means that findings of the study are accurate, and they represent a true reflection of what was being investigated. The following sub-topics will be discussed, informed consent, confidentiality, reliability and validity of the study. Lastly the limitations of the study will be highlighted.

## 4.12. Informed Consent

In order to mutually shape the research and the results, a dialogue should be done to ensure informed consent (Mills, 2011). Informed consent reduces the likelihood of participants being exploited by requesting them to take part in the research without fully understanding the requirements of the study. MacMillan and Schumacher (2006) noted that informed consent is achieved by providing the participant an opportunity to withdraw their

participation at any time with no penalty and entails full disclosure of any risks associated with the study. All participants were fully informed of the nature of the study and it was made clear that they had a right to withdraw their services at any given time without fear. All participants were well informed that they are not compelled or coerced to take part in the study. Consent was gained from the school and the teachers and the researcher explained that they were participating voluntarily in the study without any form of compensation.

When one enters an institution to gather some information, to have contact with people and to observe, it is a requirement that one obtains permission in order to get assistance of any form and in various ways. This goes a long way in protecting the participants and the researcher from any form of danger. The researcher also made sure that participants were not discriminated against due to their race, gender, religion or language as stated in the South African Bill of Rights (1996).

## 4.13 Confidentiality

Marshall and Rossman (2011, p. 47) argue that, "respect for persons captures the notion that we do not use the people who participate in our studies as a means to an end and that we do respect their privacy, anonymity and their right to participate." It is crucial that confidentiality of data and their anonymity is maintained throughout the research. The researcher guaranteed participants of their privacy, anonymity and confidentiality during and after the study. It is vital that the privacy of all participants is protected hence the researcher used pseudonyms for all the participants taking part in this study. Researchers believe that participants should not only be assured of complete anonymity but they should also feel completely free to voice their true feelings and views without fearing condemnation from the interview. Only if there is mutual agreement and honour between two parties are the chances good for the participant to freely reveal his or her innermost feelings and beliefs to the researcher. Welman et al. (2005) state that there must be no way for the researcher to identify who said what. In terms of confidentiality, it simply means no one may gain access to individual data or the names of the participants except the researcher. It includes making sure that collected data cannot be linked to any participants. The researcher made use of pseudonyms to allow participants to participate freely knowing well that they will not be exposed. As suggested by MacMillan and Schumacher (2006), the researcher tried to protect the privacy of participants by storing collected data in a secure locker. The data is kept there for use later and will be destroyed after the data analysis.

## 4.14 Reliability and Validity

Reliability and validity are crucial aspects in qualitative research. Maree (2007) argues that when researchers speak of research validity and reliability, they are usually implying that the research is credible and trustworthy. Cohen et al. (2007) state that validity is how well a variable measures what it is supposed to measure and reliability is the test of how well the findings can be produced. Putman and Rock (2018) cite that, when something has validity it is deemed to measure what is intended. Reliability, on the other hand, is referred to as consistency of measurement. This simply means that one can obtain similar scores across multiple instances of measurement of some variable. It also means that the researcher can provide a true picture of the situation.

Reliability and validity work hand in hand within the research process. If a researcher develops a valid instrument, but fails to administer it properly, then results may not be reliable. In conclusion, Putman and Rock (2018) mention different factors that could cause errors in research. Such threats include subject reliability, situational reliability, instrument reliability and data processing reliability. The researcher is aware of these threats and has tried to minimise the likelihood of encountering them.

It would have been better to spend more time in the field to enhance validity however that was not possible since the researcher is an educator and had to be at work. Only five weeks study leave was granted by the school. During observation the researcher kept checking with the participants if she had captured data accurately. All three data collection methods were collaborated for collection of valid data.

## 4.15 Limitations

The research study had its own limitations as it was carried out only in one school. It would have been ideal to carry out the study in different schools of different types like public schools, private schools and independent schools as they have different environments and the results collected could have been representative in nature.

The first option was to focus on fifteen teachers in about five schools that combine traditional methods and technology integration into their lessons. However, out of these schools approached, only three of the schools had teachers who possess skills for using the technology-based tools. The challenge faced by most of the schools is that teachers are not yet trained to integrate technology into their lessons. This made schools unreceptive of the

researcher, they made it clear that they were not yet confident in using the technology-based tools and were in the process of being developed through attending internal workshops. The other schools pointed that the teachers were very busy at that time and could not have a researcher on site. Other schools pointed out that they only had computer laboratories that are used as research centres. The researcher had no option but to choose participants from one school willing to accommodate her. As the study was carried out in only one school, it is not possible to generalise the results. However, Merriam (2009) argues that the qualitative approach allows the use of a small group of people if there is current focus within a real-life context.

During the observation process the researcher met a few challenges. These included unexpected changes in the school. Such changes included learners being required to attend services outsourced by the school for example, study skills programme, having an assembly for an important event/announcement or the whole class going for an educational outing. Prior to commencement of data collection, the timetable had been sent to all participants by the Head of Department through emails. The researcher would arrive for observing the lesson in a certain grade only to be notified of such events when she was already there. There were also participants who forgot to check the timetable with set dates for the researcher and this was a great inconvenience to the researcher. Other disruptions included the teachers' computer being faulty and then arrangements to move into another class would have to be made. This took time and it would disrupt the observation of the integration of technology-based tools into the lesson. The researcher also noted that not all mathematics lessons were taught using technology-based tools hence if the teacher does assessments and any other activity she/he would not use the tools. This was however not done by all participants as some preferred using technology-based tools even for assessments. Participants' absence for a lesson due to reasons beyond their control, for example, absenteeism due to ill health was among the factors however it only occurred twice during the five-week observation period.

Another limitation was that the study involved technology-based tools which cannot always be used due to different reasons. There are lessons that were disturbed during data collection as the computers would become faulty at an unexpected time like during the lesson and the teachers had to call technical personnel to assist them with the problem. This meant that mathematics lessons would be over, and the researcher would have failed to collect data for that day.

The other limitation was that there were instances where mathematic lessons clashed with other school activities as the learners had to attend urgent meetings or go for a trip. This also meant moving the lesson to another day. The other limitation was that the interviews were done in the afternoon after dismissal time. This seemed to be an inconvenience to the participants as they had other commitments pertaining to their class work. The participants accommodated the researcher to collect the information through their hectic schedules.

## 4.16 Conclusion

This chapter defined the research methods and the research paradigms that were employed for this study. The chapter clearly laid out the research questions that the study seeks to address and furthermore spelt out the importance of seeking consent to carry out the research from relevant bodies. Issues of how the sample was drawn were also discussed. The researcher explored reasons for choosing purposive non-probability samples and further explained what the researcher preference would have been. The interpretive research paradigm was highlighted with reasons laid out as to why it was chosen.

The chapter also presented the importance of observing ethical issues which included participants' privacy and respect for the rights of individuals. The researcher further laid down all the procedures she took to make sure that data collected from the identified participants is not used for anything else but solely for this research study. Data collection methods discussed included interviews, questionnaires and observations. The chapter also discussed at length the procedures that were followed by the researcher to address issues of validity and reliability to ensure that the study was authentic.

# Chapter 5
# Data presentation and analysis

## 5.1 Introduction

In the preceding chapter, the research methodology utilised in this study was discussed in more detail. The reasons for choosing the research design and the sampling process were also outlined and were followed by exploring data collection techniques, ethical issues, validity and reliability undertaken by the researcher.

In this chapter, the researcher focussed on analysis and interpretation of the data obtained from questionnaires, interviews and observations. The chapter presents the findings of the study which explored the integration of technology-based tools in Intermediate Phase mathematics classrooms. Data collected from observations, interviews and questionnaires was reviewed, compared and constructed. According to Miles and Huberman (1994) analysis consists of three current flows of activity: data reduction, data display and conclusion drawing. The research questions (see subsection 1.7 for the research questions) guided the researcher to identify key areas for analysis.

The participants who took part in the study used technology-based tools to deliver all their mathematics lessons. Three participants answered the questionnaire, seven participants were observed integrating technology-based tools into their mathematics lessons and four of the seven participants took part in the interviews. The participants identified the tools which they are using in their classrooms, gave reasons for using the technology-based tools and further described how these tools are being integrated to enhance teaching and learning of mathematics. The chapter opens with a summary of participants' information and further discusses themes that emerged from all three data collection methods

## 5.2 Technology-based tools used in mathematics classrooms

Participants were given questionnaires to answer which included open-ended and closed-ended questions. The questionnaire consisted of Section A with closed-ended questions and Section B with open-ended questions. Participants were asked to identify technology- based tools that are integrated into their mathematics lessons. According to Shelly (2008) technology-based tools are being continually upgraded and have a huge influence on the teaching and learning environment. These researchers further mentioned that technology-

based tools can be used for communication purposes at home, at work and can assist in delivering information to learners, in a more comprehensive and clearer way. Responses about technology-based tools used in mathematics classrooms were obtained through interviews, questionnaires and observing participants using the tools. The following are the technology-based tools that are being used by participants in mathematics lessons:

- The iPad
- The projector.
- The whiteboard/ The Interactive Whiteboard (IWB)
- Teacher's laptop or the desktop / The internet

All participants use the listed technology-based tools in delivering mathematics lessons and these tools are mounted in each classroom. Most learners have these tools at home, and they seem to have great knowledge on how they operate as they use them frequently. Bringing these tools to the classroom therefore makes great sense, as learners know and are interested in what these tools can offer. If learners have shown so much interest in these tools, there is no reason why they cannot be used for the purposes of teaching and learning especially in mathematics that has been termed a difficult subject by many. One of the technology-based tools used at the participating school is the iPad.

IPads are ideal for learners in today's world and the researcher believes that it is a great tool for teaching mathematics. Most learners (especially in towns), if not all, are used to their smart phones hence it becomes easy for them to work on iPads with little assistance from the teacher. Participants were asked about technology tools that they are using in mathematics lessons and their responses were as follows:

> Lilac: *"...each boy has his own iPad and there is a mathematics folder in each iPad...most work is available electronically..."*

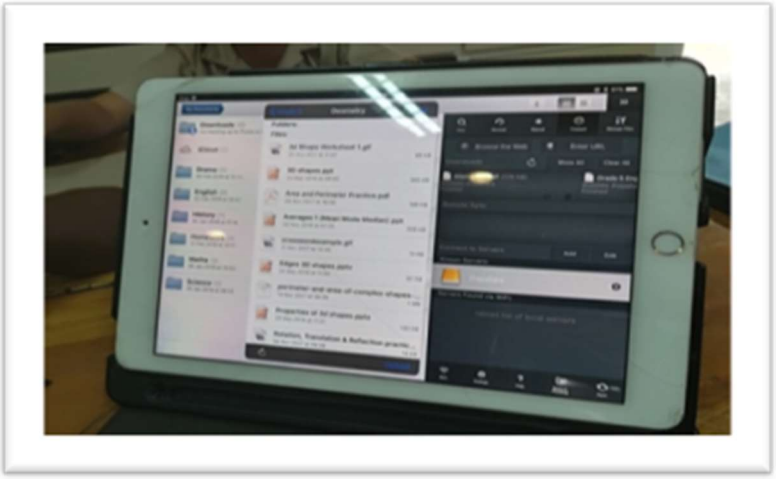


***Figure 2: An iPad used by one of the learners at the participating school.***

Each learner at the participating school owns an iPads which are purchased by parents upon the enrolment of the learner at the school. IPads are becoming more popular in many schools as they are easily available on the market, are easy to use and are mobile. These tools have diverse applications and they are flexible in that they can be used both at school and home. These may be cost free or cost very little, making it affordable for many parents. Attard, Mountain, and Romano (2016) pointed out the positive influence that iPads have on the teaching and learning environments as they support student engagement, however, he cautioned that their effectiveness may largely depend on different types of applications being used.

The participating school provides learners with Wi-Fi and different mathematical applications are downloaded and installed on each iPad. During lesson observation learners were assisting each other in finding applications quicker. The school put measures in place on internet restrictions to protect learners from any harmful content. This is because the internet offers comprehensive information, some of which is useful and sometimes harmful content hence the need to guide young learners. During the entire observation period no learner was seen with a cellular phone, however, Gikas and Grant (2013) argue that if a cellular phone is utilised properly as a learning tool it can serve various purposes in the learning environment. Participants at the participating school maintain that the iPad and the phone play the same role hence there is no need to have cellular phones.

Other technology-based tools used at the participating school include the interactive and non - interactive whiteboards. Whiteboards play a large role in the classroom as they enable teachers to improve their teaching practices and therefore guide learners to understand abstract concepts (Mauro De, Lieven, & Jan, 2014). Observing teachers using whiteboards, especially the interactive boards during their lessons made the researcher realise how much more these tools can give as compared to the chalkboard, for example, showing opening 3D objects on interactive boards to show their nets.

Participants had this to say concerning the whiteboards,

> Lily: "*…I make use of the whiteboards and also project number sense workbooks on interactive whiteboards and on learners' iPads…*"

> Aster: *"...interactive boards are amazing, I use technology tools to teach all subjects..."*

In his study, Karsenti (2016) describes an electronic whiteboard as a technological tool which displays content from a computer or any other source of information. Current whiteboards have a touch screen which makes it easier for content projected to be moved around using a finger or a special pen that comes with it.

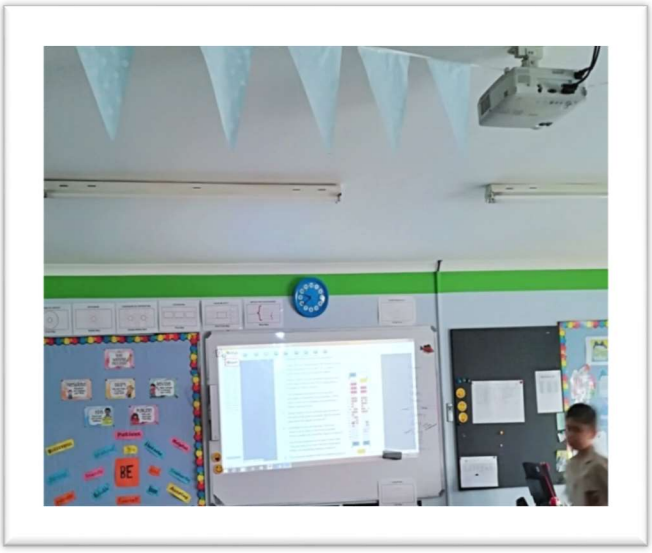


***Figure 3: A projector and the whiteboard used at the participating school.***

Studies reveal that the interactive whiteboard is an effective tool however, its effective use depends on the available resources as well as the teachers' ability to make maximum use of it in the learning process (Warwick, Mercer, Kershner, & Staarman, 2010).

The other technology-based tool used at the participating school is the projector. Each class has a mounted desktop and a projector which works with the whiteboard. According to the participants, the desktop in each class is upgraded as per need. Projectors can produce information using motionless images like slides or the ones that are moving like videos. Most learners have fun learning through seeing these images especially on a big screen. The projector allows for visual display of bigger images which create easier views and keeps the learners' interest. Illustrating an abstract point becomes possible and easier if the projector is being used in mathematics lessons.
The projector is used in several ways by different teachers and this is what the participants shared as is evident in the transcripts that follow;

Violet: "…*to project NumberSense workbooks*..."

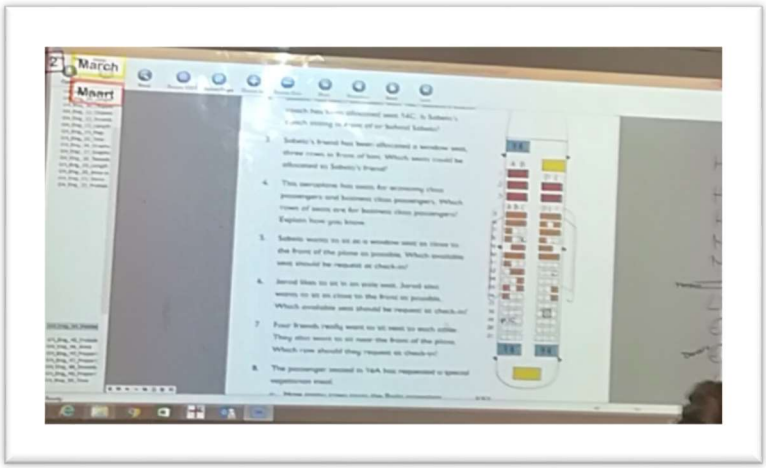



**Figure 4: NumberSense workbooks projected on the whiteboard.**

Besides projecting NumberSense workbooks, teachers in the participating school use the projector for PowerPoint presentations. One of the responses from a questionnaire by Daisy indicated that she makes use of PowerPoint on Twinkly.co.uk to which the participating school subscribes on a monthly basis. This gives all the teachers access to teaching materials like interactive activities, mathematics resources, PowerPoint lesson plans and much more.

Each learner is provided with two sets of NumberSense Workbooks, one on Numbers, Operations and Relationships and the other on Measurement, Geometry and Data Handling concepts. Patton and Burmark (2000) argue that multimedia projectors are becoming a centrepiece of classroom technology hubs that engage learners directly and add impact to each lesson.

The introduction of technology-based tools has made life in the classroom easier for both the teacher and the learner. The 21st century classrooms have turned into interactive environments where teachers and learners are partners in the learning process. Learners do not rely solely on the teacher for information, but rather a teacher acts as a shepherd and a coach. The researcher has noted that technology use in the learning environment has grown rapidly over the past decade and it continually enhances teaching and learning in the schools. Technology integration is inevitable, even though there are still mixed feelings about bringing mobile devices into the classroom.

When asked how the participants feel about using technology tools to teach mathematics, one of the participants indicated that in the beginning she lacked technological knowledge, was fearful and found the use of tools challenging. She was dependent on other colleagues for assistance. However, as the participants received regular training on the use of the tools, they became more confident and began enjoying the benefits of using the tools in teaching mathematics. It became clear to the researcher that having content knowledge and pedagogical knowledge is not enough if the teacher lacks technological knowledge. During the interview the participants mentioned the importance of receiving training in technology integration;

> Lilac: *"...the first few months of using the whiteboard was quite a challenge, it seemed difficult as I had not been exposed to that before, however after getting training on a numerous occasions and also collaborating with other colleagues all was in place. I now enjoy integrating these tools into my lessons and even wonder how teachers without tools are managing. I enjoy what I do..."*

Hong and Thomas (2015) believe that learning and teaching mathematics with technology is a complex process requiring a teacher to marshal several key competencies. They further point out that the attitude, confidence, ability and beliefs about mathematics and technology can be other factors which lead to fear of technology integration. Kisalam and Kafyulilo

(2012) state that teacher development programs should involve formal and non-formal workshops, where innovation–related challenges are highlighted and discussed during the entire development course. Technology training in the participating school has given all teachers confidence to use the interactive whiteboard in their mathematics lessons and collaboration with other teachers makes it an understandable and enjoyable experience. Frequent training of teachers (interviews) has a positive impact in lesson delivery as teachers showed confidence in making use of the tools.

The researcher believes that the underlying beliefs on the use of technology tools impacts negatively on their integration into lessons. Fear of change from the usual old ways of teaching is also a contributory factor. The relationship between technological knowledge (TK) and pedagogical Knowledge (PK) plays a large role in the classroom (Koehler, Shin, & Mishra, 2012).

## 5.3 Exploring learner engagement

Effective learning happens when learners are fully engaged in the learning process. Engaging students may not be an easy task for some teachers. When learners' engagement is compromised it then becomes a challenge to teach effectively. Ismail and Groccia (2018) argued that student engagement includes the time and energy students devote to educationally sound activities inside and outside of the classroom. In order to actively engage learners, teachers create instructional methods that allow learners to participate in meaningful activities. Effective teachers avoid using methods where a child passively receives information from the teacher without grasping concepts being taught. It is therefore vital that teachers purposely plan how to integrate technology-based tools in mathematics classrooms in a way that fully engages learners.

The researcher was interested in why the technology-based tools are used in mathematics classrooms and responses from the interviews were as follows,

> Rose: *"...my learners are fully engaged throughout the lesson and they participate well..."*

> Violet: *"...use of the iPad and the interactive whiteboard engages the learners fully..."*

Engaged learners can be seen by paying attention during the lesson, they are able to participate by asking and answering questions or giving their own views freely. In Daisy's class, the researcher noticed that most learners were interested in the given tasks, they were interacting with each other and calling for assistance from the teacher. Furthermore, learners' interaction was not confined to the groups they belonged to, but they were able to check if they were doing the right thing by keeping track of what others were doing. Once all groups were finished reporting, the last group preferred to show their information on a PowerPoint presentation. All learners showed enthusiasm and were motivated to learn. The technology-based tools being used in the classrooms assist learners to stay focused as there are various activities. This is also evident in the interview transcript that follows;

> Azalia: "*…it is different, their interest is captured and the lesson moves quicker without us (teacher and learner) noticing. ….There are a few behaviour challenges that I deal with…"*

Increased engagement in the learner can cause increased learning which in turn improves the academic performance (Skilling, Bobis, Martin, Anderson, & Way, 2016). In the past years tools like the phone were deemed to be disruptive in the classrooms but nowadays these tools play a large role in the teaching and learning environment. It is these tools which capture the learners' interest and increase their participation and the level of creativity. Mathematics classrooms where technology tools are used give each learner an opportunity to explore the learning environment with ease (Chipangura & Aldridge, 2017). argue that a learning environment in which more tools are used to help create mental models that meaningfully interconnect verbal and pictorial communication, have the potential to engage learners and capture their attention. Imms and Byers (2017) argue that more dynamic and adaptive spaces, together with the use of technology-based tools, have a significant effect on student engagement. When students are engaged and have interest in what they are doing, they have less time to fool around in the classroom hence their behaviour does not become a challenge.

Groccia (2018) also points out that when learners become fully engaged in the process of learning, the cognitive, behavioural and emotional domains are more likely to be influenced. It is in the technological environment where these three types of student engagement are taken care of. (Bobis, Way, Anderson, & Martin, 2016) affirm the importance of instruction for enhancing student engagement in mathematics classrooms and further consider

engagement not to be solely a student's responsibility but also of a teacher who purposely plans how to engage a students from the beginning to the end of the lesson. (Bobis et al., 2016) believe that engaging students in the learning process is a critical issue in improving learning outcomes.

## 5.4 Exploring visualisation

***"I hear and I forget. I see and I remember. I do and I understand." Confucius***

Teaching abstract concepts in mathematics has indicated major stumbling blocks in the teaching and learning of mathematics (Uvisha, 2017). As such, traditional teaching methods are being improved and new methods have been introduced and tried in different learning environments. In his study, Elliot (2001) argues that visualisation is the process of forming and creating pictures, images, and diagrams in the mind. These pictures have the potential to unlock understanding and may assist the learner in grasping concepts being taught. This is done with the purpose of depicting and communicating information, so that previously developed unknown ideas and advance comprehension skills.

The researcher believes that mathematics classrooms can be successful if abstract concepts can be brought into reality through different ways. Content presented in the form of images helps the learner conceptualise abstract concepts with better understanding. The researcher noted the power that technology-based tools hold in assisting the learner to develop internal images and symbolic representations that can be used later. Visual images play a large role in grasping mathematical concepts. When participants were asked why they used technology-based-tools, they responded as follows:

> Rose: *"...I find that if learners have seen a picture or a diagram especially a colourful one it's not a challenge for them to remember…without visuals most concepts in mathematics would not make sense to most learners… maybe it's one of the reasons why mathematics is being failed at a high rate…learners struggle to grasp the concepts if they are taught in an abstract manner…I teach concepts like capacity and volume using colourful images and learners find it easy to remember …"*

Orchid*: "…there are some concepts like capacity and volume that can't be explained abstractly… when taught using pictures, permanent images in their minds can't be deleted..."*

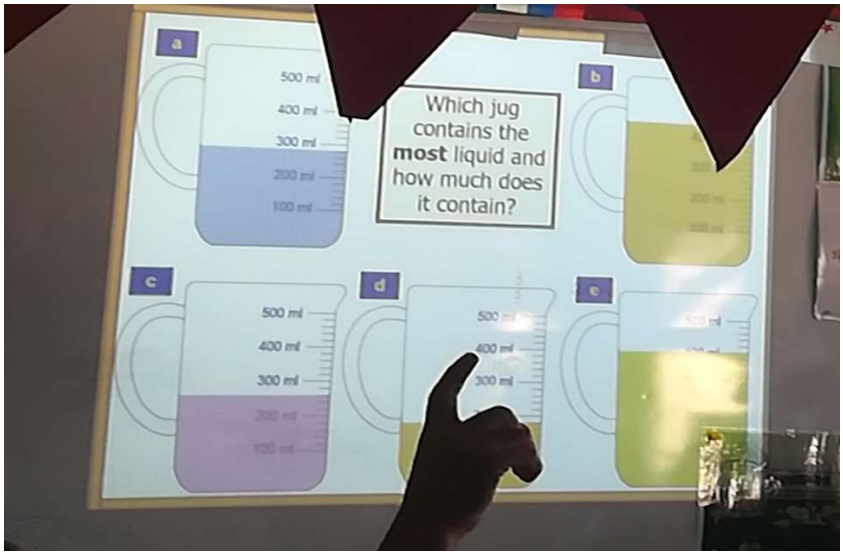



***Figure 5: Different containers showing volume (use of colourful liquids)***

Figure 4 shows images of containers with capacity and volume. In the Grade 4 class, the participant taught capacity and volume. She showed the difference between the two using different colourful liquids to fill up the containers on the screen. Learners were also given a chance to fill up the containers to show different volumes. Use of colour excited the learners and they could be heard saying the names of different liquids depending on the colour of the liquid used to fill up the containers

Gathesole & Alloway (2008) argue that teaching using images has the possibility of developing and strengthening the learners' imagination which may help the learner to form and organize mathematical concepts. They further point out that visualisation is assumed to have played a vital role in problem-solving and general working memory. Other researchers (Chaimaine, 2011; Touw, 2019) also argued that concentration and attention may be heightened by use of colourful moving images. The concrete representations offer a closer correspondence with the described situation hence promoting better performance in mathematics classrooms. Thus, in order to teach mathematics effectively, the explanation of concepts must be aided with concrete objects or images must be used to help the learners to visualise the concept. Orchid used an interactive board to show the difference between a two-dimensional and a three-dimensional shape. The cube shown on the whiteboard was

opened and different learners were asked to put in marbles of their own choice. The teacher went on to compare it with a square which is a flat shape and gave learners a chance to look at three dimensional shapes on display. Learners kept referring to shapes which were shown on the interactive whiteboard. They were fully engaged and showed interest throughout the lesson;

> Azalia: *"…this is what technology does, it brings images into reality as learners can see colourful pictures with their own eyes…They learn better by seeing images and eventually they form concepts and this even helps the learner who is slow in grasping concepts…and at the same time motivating the fast learners…*

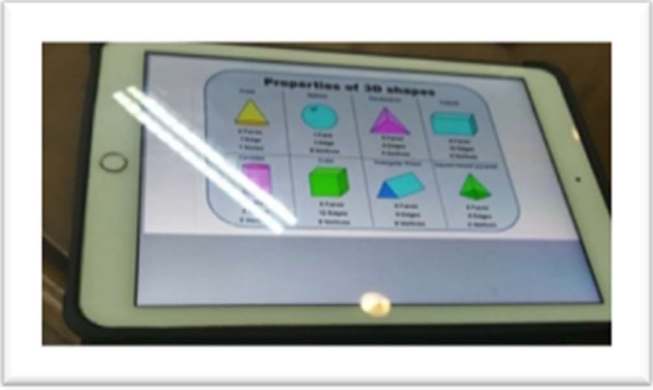



***Figure 6: Visual learners can see colourful 3D shapes.***

The transcripts from the questionnaire from other participants were as follows:

> Lily: *"…they see something and it sticks in their minds. A passionate and creative teacher knows that. Our interactive boards are excellent when it comes to that…"*

For most learners it becomes easier to remember what they have seen. The use of images cannot be ignored in mathematics classrooms as it is one of the successful methods of assisting learners to fully grasp the concept. When referring to previous concepts, the teacher mostly described a certain picture to remind learners which assisted them in remembering. After the lesson, the learners had a folder of shapes, they would read the characteristics of a certain shape and at the end say what the shape is. For each correct answer the picture of that shape pops up (on their iPads) and they move to the next one. Emmanuel (2011) argues that visualisation is a powerful tool in mathematics used in different classrooms to support the understanding of the concept by letting learners visualize through picture representation.

He further points out that technology tools have raised the possibility of visual representation which plays a huge role in mathematical reasoning, investigation and argument. The use of colourful images and pictures is beneficial to the learners in mathematics classrooms.

## 5.5 Catering for diverse learners

Providing inclusive classrooms in today's teaching and learning environments is key to embracing learners with diverse needs as no learner is the same as the other. Teachers should, therefore, develop a plan to suit specific needs of individual learners. Learners are different in terms of physical, emotional and behavioural needs. Different as they are, all learners deserve to be given an opportunity to fully benefit from the learning environment to become the best they could be. This can be made possible if a teacher has appropriate work for all learners regardless of their different abilities. One of the teacher's roles is to maintain diversity which is found within the teaching and learning environment and leads them to feel as a part of the classroom, gaining a sense of belonging in the process. Learners are diverse in terms of their personalities, learning styles and experiences (Landsberg, Krüger, & Swart, 2011). Students learn in various ways and have different needs which need to be fulfilled at the end of the lesson. It takes a passionate teacher, with the help of resources to reach out to all learners at the same time. Without proper planning and adequate resources diverse needs of learners cannot be fulfilled.

Technology integration accommodates diverse learners by allowing them full access to the curriculum. The participants indicated that it was not an easy task to satisfy both high and low achievers in the same lesson even using technology. They have devised different means to reach out to individual needs using the iPad and the interactive whiteboard. They indicated that this must be planned for in a creative manner.

In trying to answer why technology is integrated in mathematics classrooms, one of the participants responded as follows:

> Orchid*: "…I always try new things each week, from pictures to YouTube videos. It has become easier to cater for all learners' needs because of interactive whiteboards…"*

Learners showed that they like watching videos as they became happy each time a teacher promised to allow them to watch one. During observation one participant made learners

watch YouTube videos at the beginning of the lesson to capture their interest or at the end of the lesson to consolidate the concept. Learners could be heard reminding each other that they needed to listen to the teacher in order to avoid having this privilege withdrawn. This showed the researcher how learners look forward to watching a video. In one of the classes it was exciting to note that after watching the video they would ask questions wanting to know more which gave the teacher a chance to reinforce concepts. It further helps to challenge high achievers depending on what has been shown on the video. Watching videos caters for both auditory and visual learners and helps them to remember concepts easily. The following is a picture of one of the videos that was watched by the class:


***Figure 7: Grade 6 learners watching a YouTube video (Maths Antics) at the participating school***

During the interview the other participant pointed out that:

> Rose*: "…as small as they are (classes) each child has a different need, some learn better when they actually visualise and others prefer to see and touch for them to grasp the concept…"*

When responding to the questionnaire, one participant indicated that most of her learners were different in terms of preferences and learning abilities. Technology integration helped her to reach out to each learner. A few learners who are high achievers completed their work early and were directed to open another folder with extension work which was a little challenging. This work was tailor made specifically for them. During the lesson, as a way

of motivating one learner to complete his work, the teacher promised to give him a chance to share a recording of himself reciting the nine times table with the other learners. The teacher then wrapped up her lesson with a YouTube video which was exciting to all learners. The video shown to the learners consolidated the concept that had been taught. Showing the video catered for learners with different learning styles: the visual and auditory learners.

Catering for different learners could be hard to attain in a traditional classroom, Koc (2005) affirms this by pointing out that everybody has different learning styles for meaningful learning, but teachers cannot represent all the styles in a traditional classroom. Technologies in the classroom assist the student to manage and construct their own representations of knowledge in their minds. During the interview one of the participants affirmed this by saying:

> Azalia*: "...technology helps me to cater for x. y and z ... with different learning styles...some learners are visual learners while others are auditory, all are catered for..."*

Researchers argue that teachers using technology tools make use of images, varying text, audio, animation and videos. Ford (2018) further advised teachers about the need to plan lessons that provide multiple means for representation, expression and engagement. This is beneficial to the learners as they have different ways of approaching learning tasks, processing and expressing knowledge. Technology is rich in diversity of the world and exposes each child to a variety of things as each class is filled with a wide range of strengths, interests and needs. Taking a differentiated approach to instruction accommodates learners' differences by tailoring teaching to their strengths and knowledge as the teacher brings tasks of varied levels of difficulty. Other researchers argue that differentiated instructions give students multiple options for taking in information, making sense of ideas and expressing what they learn. Technology promotes differentiation as it provides various avenues for students to acquire content and process ideas.

Wahl, Duffield, and WestEd (2005) believe that using flexible technology to meet the needs of diverse learners cannot be overemphasised. Technology offers learning through music, which is a powerful learning motivational tool. The researcher believes that there is always something appropriate for the student regardless of his/her ability. During the lesson some learners could work at their own pace as they were given work that suits their capability. The use of iPads becomes beneficial as it is possible characteristics; using technology to

motivate people, using technology to enrich learning to tailor-make even the assessment tasks for both high achievers and those who are academically challenged. Keppell, Hard, and Suddaby (2015) define technology enhanced learning environments as having four resources, using technology to implement learning and instructional strategies and using technology to assess and evaluate learning goals.

Meldrum (2018) believe that computer-based assessment has many advantages including improved learner motivation. Teachers in the participating school can set individualised tasks according to their abilities. Normally learners are given these tasks in different categories without revealing that the assessment tasks are different. Such informal tasks help the teacher check how much of the concept was understood by the learners. These tasks are saved in the folder and learners are given a chance to answer questions on their own.

## 5.6 Integration of technology-based tools in mathematics classrooms

Participants shared how they integrate technology-based tools into their mathematics lessons. Not only do they use them in mathematics but in all subjects that are taught in the school. Participants pointed out that technology is not only for the learner, but a tool that has come to aid both the learner and the teacher in many respects. Achieving learning outcomes set in the curriculum is of utmost importance and these tools play a large role in the teaching and learning environment. Some participants believe that the workload feels much lighter and their passion for teaching is enhanced. When asked how they integrate technology into mathematics lessons, participants' responses were as follows:

> Azalia: *"...I partner with my learners when it comes to technology integration…preparation of the topic to be covered, introducing a lesson, developing the lesson and sometimes when concluding a lesson…showing a video clip or alternatively asking them to use their iPads to do research to consolidate the concept covered…"*

> Daisy: *"…audio books, games, quiz activities and PowerPoint presentation…"*

> Aster: *"…I give homework, setting and marking assessments…learners complete exercises on the iPads…there are various maths programs uploaded..."*

Lilac: *"...whenever I find something interesting on the internet I upload... collaborating with other colleagues…I always have something exciting for the learners…I go an extra mile to make the subject easy and more interesting to learn…"*

The researcher noticed that technology tools are integrated into almost all mathematics lessons in various ways. These include preparing meaningful lessons, preparing and administering assessment tasks, showing images or pictures, showing video clips to illustrate a point or a concept, projecting NumberSense books, PowerPoint presentations, mathematical games and many more things. The researcher observed that all participants easily integrate these technology-based tools due to continuous training with which they are provided. It was noted that learners partner with their teachers to successfully integrate the tools into their lessons and they enjoy doing so.

In her study, Polly (2011) felt that technology makes teaching easier and more flexible as it has power to display a variety of things. She further points out that the power of technology enables teachers to model and demonstrate different concepts helping learners to understand mathematics. The internet has very rich mathematical tasks and activities which can be used to enhance teaching and learning and all teachers need to have is the skill to choose the ones that are appropriate. Fu (2013) believes that the use of technology not only changes the traditional ways of teaching but requires teachers to be more creative in adapting and customizing their teaching materials and strategies. In his study he pointed out that learning and teaching these days no longer depends on printed materials exclusively but multiple resources like video clips, audio sounds and visual presentation can be extracted and displayed from different technology tools. In the participating school it is evident that technology tools are being integrated in various ways in different classrooms depending on the competence of individual teachers.

During the observation period one of the participants indicated that these tools also help the teachers to do preparations for their class work. Preparedness is one of the significant characteristics of an effective teacher in mathematics classrooms. To avoid presenting a haphazard lesson, teachers are encouraged to take time in preparing lessons that will cater for diverse needs of students in their classrooms. A prepared teacher has a way of introducing a lesson readily available, for example, an appropriate mental mathematics song to teach multiplication tables for that particular week. The participants use different

programs in their lesson preparation to assist the learner to understand mathematical concepts. When the teacher prepares valuable activities for learners in advance, he/she becomes confident as it is work that is researched and may be presented to learners in several ways. Teaching becomes interesting and meaningful which is evident in the interview transcripts that follow:

> Aster*: "...I normally prepare my lesson plans on the laptop and a variety of activities for the whole topic well in advance...all the work is saved (on the desktop) and all I do is to upload when I need it...it makes my life easier…"*

> Iris*: "…technology has assisted me to always be ahead in terms of preparation…if a teacher is absent work is already there way in advance..."*

One participant pointed out that assistive technology features found in most technology tools like calculators help learners in solving higher order skills and in dealing with problem-solving. Other assistive built-in features like the mathematics dictionary are useful to learners when working with new vocabulary or those who find the subject challenging. In the Grade 5 class, the learners who struggle with multiplication could use the iPad calculator to work out answers for long division. The participant assists such learners to concentrate more on understanding the division concept rather than being frustrated by multiplication. Polly (2014) in her article agrees that students at different levels can use technology tools to support and extend mathematical reasoning and enhance computational fluency. Technology gives individualised support to learners thereby allowing each child to learn with ease.

Even though these tools are a breakthrough in the teaching and learning environment, in one of the questionnaires, participants indicated that fear of integrating and exploring further with technology tools was a huge setback. Most researchers found that teachers tended to use technology for more teacher-centred activities, like lesson preparation and communication. Some teachers alluded to the fact that once one overcomes fear of technology, its use becomes a pleasure and gives much more than textbooks or any other traditional method would give. All participants pointed out the importance of willingness to learn new things that come with technology as it changes all the time.

## 5.7 Collaboration in the mathematics classroom

No child learns in isolation and a lot of information is shared between the teacher and the learners and between learners themselves. Collaboration in mathematics classrooms focuses on the active role of learners in the learning process. Learners can work together and share information. The teacher also helps them to re-organize knowledge and further explain concepts to help the learner gain new knowledge. In participant B's class learners were requested to choose two 3D shapes, do research on the internet about these shapes and then make a poster. It was amazing how the learners worked in groups to produce good posters. The teacher encouraged learners to check for new vocabulary on the internet. One group went a step further and used motion picture to show different 3D shapes. The use of iPads has the potential to boost learners' confidence and knowledge for using different programs and applications (Halabi, 2016).

Some of the responses from the participants about technology integration included the following:

> Rose: *"…there is a lot of interaction when learners are using these iPads…"*

> Iris: *"…learners in my class can solve problems as individuals, when they are paired with their friends or when they are in groups…I provide them with interesting work and they work with each other. You can be surprised at how creative they are when they are given all the resources. The internet exposes them to a lot of knowledge about the topic given and I allow them to do more than what the syllabus requires as long as they are not outstretched..."*

In collaboration with what the participants said, the picture in Figure 8 shows learners searching the web about properties of 3D shapes. In the process, the researcher could hear them discussing the 2D shapes which are used to build up the 3D objects.

***Figure 8: Learners collaborate on researching about 3D shapes on the Internet***

Learners are expected to take an active role in the learning process rather than being passive receivers of knowledge. Endang (2018) argue that students' individual needs are embedded in a worldwide trend of introducing student-centred educational systems, in which reasoning and problem-solving are encouraged, and individuals are enabled to address unique learning interests and needs. The teacher becomes the guide and his role is to provide a conducive environment where learners are given an opportunity to take responsibility and ownership of their learning. Such environments are bound to have resources that help learners enjoy learning and understand concepts better.

Drigas and Papanastasiou (2014) point out that Interactive Whiteboards (IWB) technology-based instruction generates a high degree of interactions that creates a new pedagogical environment among students, between students and the curriculum and between students and the teacher, thereby creating alternative pathways, through active participation. Technological classrooms promote communication as technology allows for creative interactive lessons. Cox and Graham (2009) argue that technology allows both teachers and learners to create presentations and projects through the integration of image graphics, text, animation, audio and motion video. Interaction is enhanced which results in new knowledge being formed. This is in line with the constructivist theory which seeks that the learner should construct knowledge through interaction with others. Not only does use of technology promote learner collaboration, it also promotes collaboration among teachers. Participants pointed out that:

Orchid: *"... colleagues collaborate and share some resources online…technology makes our work enjoyable …innovative teachers who are very good with technology are always sharing valuable teaching resources which support high thinking skills…new mathematical games promoting team work are also designed by other teachers and shared with us…"*

In their study, Matthew, Susanna Owens, Kiel, and Jason (2015) found out that teachers and schools that engage in better quality collaboration have better achievement gains in different subjects like mathematics and reading. He also pointed out that teachers improve at greater rates when they work in schools with better collaboration arrangements. Collaboration is good for both teachers and students. The researcher noted that when students collaborate, their self-esteem and confidence is boosted, and they learn new ideas and embrace each other's differences.

## 5.8 Positive student behaviour

Not much learning takes place in a class where learners display unruly behaviour and do as they please. Providing a productive environment where effective learning takes place cannot be overemphasized. Learners lose attention when the content being delivered is too abstract or too difficult to comprehend. They also develop disruptive behaviour if the teacher is unprepared or is lacking structure. Behavioural problems also arise when learners are left unoccupied. One way which curbs behavioural challenges is the integration of technology into lessons. The 21st century learners are technologically inclined from a very young age. They are introduced to technology from home and they can spend hours listening to or watching videos on their phones or from the television. The same strategy used at home can be transferred to the classroom. Technology tools can be effectively used to teach concepts through watching and listening to mathematical videos and teachers can then later explain the concept filling in the gaps where learners lacked understanding. When asked how technology helps them in mathematics lessons, the participants responded as follows:

Rose*: "...we don't have too many behavioural challenges during mathematics lessons…learners are fully engaged and they enjoy uploading videos of themselves solving mathematical problems as this helps them to feel good about their abilities…"*

*Orchid: "...they are occupied with interesting activities on their ipads... there is minimal negative behaviour..."*

In another interview, a participant said;

*Orchid:...yes"...mathematical games uploaded in their folders keep them busy, sometimes it gets noisy during the lesson...it's not bad noise as they will be learning mathematical concepts."*

Technology integration in mathematics lessons plays a large role in promoting good behaviour. Learners who find the curriculum pointless, meaningless and irrelevant distance themselves from the task of learning and may therefore display various forms of unacceptable behaviour (Landsberg et al., 2011). This is true even for mathematics lessons, if concepts presented are not connected to their real-life world, they tend not to pay attention. Teachers used technology during mathematics to teach meaningful lessons which caught the attention of learners. To maintain discipline during mathematics lessons, learners who perform well in oral or written exercises are offered various rewards.

Reinforcers are used by several teachers which are referred to by Prinsloo & Gasa in Landsberg (2011) as stimuli that follow the occurrence of certain behaviour and increase the probability and rate of that behaviour. The above writers further lay guidelines for applying the reinforcers, like giving them to learners immediately and considering those who are preferred by the learner. In the classrooms observed these included getting five minutes to play games on their iPads. Learners are also rewarded for behaving well during the lesson by popping up colourful positive remarks on a big screen, for example, "Mark... thumbs up for good behaviour". This is also done when any victories are being celebrated, like completing the multiplication tables accurately. Such activities improve the behaviour of the learners as they become motivated to work harder and score better points while in the process displaying positive behaviour.

## 5. 9 Learning mathematics through games via a technology-based tool

When learners' interests are considered learning mathematics becomes meaningful to them. The use of games to teach mathematics is a strategy that is used by many teachers who use technology because learners like to play. When they are engaged in mathematical games, learners who do not usually participate in class are hooked up and sometimes they do not even realise they are learning a certain concept. Interactive boards can be an effective tool for initiating and facilitating learners' understanding. These tools assist in improving learners' thinking skills, especially when learners are involved in their use. There is an obvious visual and verbal state of learning when interactive white boards are used in the teaching and learning environment. Colour and movement motivate learners and reinforce concentration and attention. In their study, Parry, Andema, Tumusiime, and International Reading (2005), reiterated that the use of games had an important influence in supporting and maintaining the learning process. They made learning fun, easier and changed their perception about mathematics as a subject:

> Orchid: *" ... at the end of the lesson I reinforce the concept with the games…My learners love to play, through play their understanding of the concept is enhanced…those who did not complete the game in class continue with it at home and learning never stops in the classroom…"*

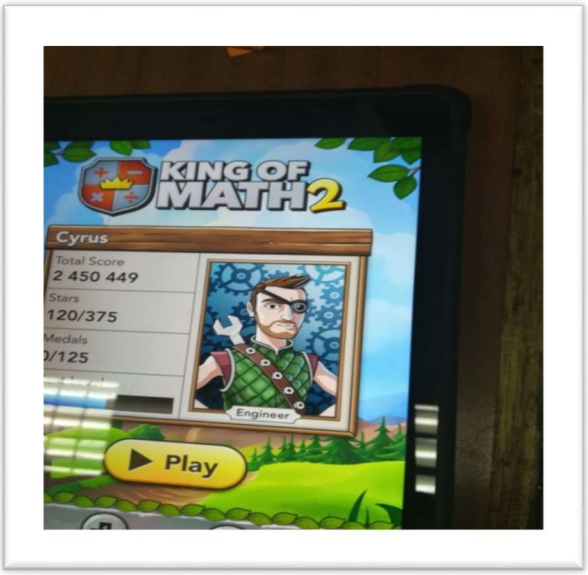



***Figure 9: A mathematical game played by a group of learners after they have completed their written work.***

The game in Figure 8 was being played by different learners in class, the teacher encouraged them to play faster and try to communicate with peers on how they will solve problems.

They could also compare their mathematical skills with others. The game was engaging, fun to play and teaches them several mathematical skills.

Mathematical games connect learning to real life situations of the given student. Some of the games are interesting as they help the child to connect mathematics with the real world. The teacher needs to realise the importance of creating relevant environments that incorporate sensible mathematics activities for learners to make sense of their world and to gain new insights. Constructivism emphasises that the responsibility of learning lies with the learner while the teacher acts as a mentor (Gilakjani, 2013). Knowledge of technology is not only beneficial in the classroom environment but also prepares learners to be active participants in the whole community as most professions now require the general knowledge of computer use.

## 5.10 Effective Teachers

A teachers' role in the classroom is believed to be holistic and is not only central to the pedagogical process but also to the socialisation of young persons. Teachers are required to possess skills that range from being knowledge facilitators, social workers to being secondary parents Sabiescu and van Zyl (2016). These researchers further believe that effective teachers should harness, and mould crucial skills required for learners to be productive members of the society. Effective teachers strive to make positive learning climates where effective learning takes place believing that each child is capable of being a successful learner. Such teachers make it their responsibility to acquire knowledge and skills about winning a learner's heart and, realise the need for on-going learning so that their teaching skills are enhanced. Effective teachers engage in continuous professional development programs as new and valuable information is brought for their attention. Each day presents itself with an opportunity to be a teacher to students and at the same time to learn new things from them. Technological classrooms present conducive environments for helping the learner to understand the subject matter and to interact with other learners who have diverse needs as instruction is differentiated. Technology integration assists the teacher to create a variety of well-designed lessons and activities which assist classroom management. This was confirmed by the participants in the interview transcripts that follow;

Daisy said; *"...Technology helps me to be an effective teacher in terms of preparing a variety of interesting lessons which fully engage my learners..."*

Iris said; *"...I research a lot from the internet, find interesting activities and prepare my work...there is on-going training with regards to technology use...it has helped me to be a productive and an effective teacher..."*

Tucker, Stronge, and Gareis (2016) believe that if a teacher has interest in students and their success, use of practical tools to ensure positive outcomes for all students must be considered. The researcher believes that these may include technology-based tools. Technology plays a large role in assisting teachers to become effective and more passionate about the work they do. Mathematics classrooms need passionate teachers who go the extra mile in preparing appropriate tasks for learners. In the participating school, the teachers created motivating activities to maintain learners' interest in the subject and perform better. The researcher further noticed that teachers prepared a variety of appropriate assessment tasks to check students' achievements and assist where they did not fully grasp the concept. Effective teachers work hard and in order to help their students perform better, they use innovative teaching methods in their classrooms.

## 5.11 Conclusion

This chapter laid out in detail the findings resulting from data collected through the interviews, observation and the questionnaire. The critical questions of the study were answered which are;

1. Which technology-based tools are integrated into mathematics classrooms and why are they being used?
2. How are technology-based tools integrated into mathematics?

In the following chapter a summary of findings that emerged will be discussed and a conclusion given.

# Chapter 6

# Findings and conclusion

## 6.1 Introduction

A summary of integration of technology-based tools in mathematics classrooms is presented in this chapter. A qualitative research approach was used to conduct the study and three data collection techniques - interviews, questionnaires and observation were adopted. The study consisted of nine participants, who are all teachers at the participating school. All participants are integrating the technology-based tools into mathematics lessons and all other subjects offered by the school. Conclusions drawn from the study will be explored and the researcher will make recommendations in line with the study. Limitations encountered during the study will also be outlined. The main findings of the research will be summarised and discussed briefly.

## 6.2 Summary of findings

Technology-based tools play a huge role in the daily lives of both the young and the old. Watching television, using the internet and cellular phones are all part of technology. More advanced technology-based tools are yet to be introduced both into our homes and the learning environment, for example blogs, google classroom, wevideo just to mention a few. The use of technology-based tools helps learners to take ownership of their own learning. Learners become self-directed and are motivated to monitor and reflect on the concepts learnt. There are numerous ways in which these tools are integrated into mathematics lessons, for example playing audio-visual material and playing games on the iPads. This increases learner participation and concentration during the lesson. Technology-based tools enhance teachers' competencies, knowledge and skills through networking with other teachers and engaging in continuous professional development programs.

This study examined the integration of technology-based tools into mathematics classrooms in the Intermediate Phase and the key questions which guided the study were:

1. Which technology-based tools are integrated into mathematics classrooms and why are they being used?
2. How are technology-based tools integrated into mathematics classrooms?

Below are the conclusions that have been drawn from the research study.

### 6.2.1 Which technology-based tools are integrated into mathematics classrooms?

The participants identified different tools integrated into mathematics classrooms in response to the above question. They indicated that the following tools - the iPads, interactive and non-interactive white boards, the desktop/laptop, and the projector are being used in the participating school. The researcher noted that each boy in the Intermediate Phase has an iPad and are used by learners both in the classroom and at home. The school gives a specification on the type of an iPad to be purchased by parents upon learner registration. An iPad is a mobile tool which allows for personalised learning.

> Orchid pointed out that; "…*I group my learners according to their abilities and send different presentations to their iPads … appropriate for that particular group depending on the concept being covered.*"

With the use of iPads, teachers can adapt to the level of each child regardless of his/her abilities. It was noted that iPads are easy to carry from one place to the other as compared to carrying textbooks and can hold much more information in different formats.

Most of the work is uploaded and saved on the iPad for use whenever needed. Each iPad has different folders where the work is saved, including a homework folder, an assessment folder, a folder with mathematics videos and mathematical games. Having work on the iPads assists with ease in transmission of work from the teacher to the learners. One other important use of iPads is for administering assessments.

> Lily pointed out that; "…*sometimes assessment tasks are done on the iPads and the teacher can do marking and give feedback immediately".*

Assessments are significant for determining whether learning has occurred effectively or not. Furthermore, they point out areas that need reinforcement. An assessment guides the teacher in setting goals and planning for different learners with different needs. Teachers can to create assessments in a variety of forms Thompson, Burton, Cusi, and Wright (2018) and they can mark and provide feedback timeously. The researcher noted that some of the formal assessments are set on the computer, printed and the question paper written in class.

iPads are also a great tool in the sense that educational games can be uploaded for the learners to play with in and out of school. Educational games have been used to promote learners' mathematics achievement in various domains like problem-solving, algebra skills, strategies and reasoning abilities and geometric skills (Fokides, 2018). The researcher observed that most games teach learners how to add, subtract, divide, multiply, count

backwards and forwards which skills are acquired while having fun. Once these games and other applications, like the mathematics dictionary, Power Point and many more others are downloaded, no internet is needed to access them at a later stage making it easier for the learner to practice mathematics in different places. Having a mathematics dictionary may be helpful in terms of defining new vocabulary that learners encounter when dealing with different topics. Riccomini, Smith, Hughes, and Fries (2015) argue that mathematical proficiency can be attained through learning mathematical vocabulary as it is a very important part of their language development. In-built functions that come with the iPad, such as the calculator are also very beneficial to the learners. These assist learners with calculations especially the learners who are not accurate when it comes to operations.

Learners seemed comfortable using these tools during mathematics lessons and could be seen assisting each other with finding programs on their iPads. Teachers can save work in advance and download it whenever needed to be shared with learners during class time. The researcher noted that one other advantage of using iPads is that a lot of paper is saved, as there is less printing of worksheets. The tool has enough space to store a lot of information. These tools are found by learners to be easy to use as they attract and engage learners throughout the lessons which in turn enhances their performance in mathematics. Sawang et al. (2017) concur with the above statement by stating that current responsive technologies may lead to greater use and increased levels of students' engagement levels. Warmer (2018) says it remains unclear whether actively engaged students without technology would perform as well as actively engaged students with a technology. The researcher saw that all the iPads screens were protected by screen guards as fixing the cracked screen each time the learner dropped the iPad would have been very costly for parents.

Participants highlighted that they also use whiteboards which work together with the projectors and the desktops or laptops. These tools are very interesting to the learners and have a lot to offer in teaching mathematics.

The following excerpts show different technology-based tools that are integrated into mathematics lessons,

Lily highlighted: *"...we use the whiteboard to teach all subjects at our school…*"

The school has been using both interactive and non-interactive boards and upgrades for all classes are underway. The interactive board engages learners and encourages involvement as they can also work on it. It allows for more than one user and learners feel good when

they get involved during the lesson. Interactive boards also help to teach abstract concepts with ease.

> Aster indicated that: *"... when teaching about 3D shapes, learners need to see the images of 3D shapes in detail and in different angles, and this may also include rotating shapes to show the base, their sides, their edges and their vertices*."

The researcher noted that it then becomes easy for the learner to understand and grasp the concept. When asked about properties of different 3D shapes most learners could identify them with ease and they were later able to draw these shapes on the iPads. Interactive boards have a touch recognition function which allows the teacher or the learner to use a finger or a special pen that comes with the board. The pen tray holder usually has pens with different colours. A smartboard is a presentation device that interfaces with a computer displaying computer images on the board by a digital projector where they can be seen and manipulated in different ways (Cole, 2006). Teachers can manipulate the board in several ways including adding notations, using a highlighter tool, writing, erasing, performing mouse functions with their finger or pen, capturing and saving their work all of which tools are relatively easy to use. Creation and preparation of lessons can be done at home prior to lesson presentation.

> Orchid pointed out that: "…*I can click on a picture to open, zoom, highlight or move it in any direction*…"

This function helps the teacher to elaborate on concepts and is also very beneficial to visual learners, who are the majority in the classes.

Interactive boards also have an animation feature, whereby pictures are manipulated to appear as moving images which are very exciting to the learners as they serve the same purpose as that of the television which is much liked by all the learners. Research shows that animation may lead to enhancement of motivation, gain learners' attention and at the same time support cognitive processes.

The school provides teachers and learners with the internet which is essential in the 21st century learning environments as it provides teachers and learners with plenty of information. Learners are trained in how to search the web in a reasonable and responsible way and sites with inappropriate information are blocked from being accessed by learners. The internet allows the teacher and the learner to access information easily. Mayfield and Ali (1996) argue that making use of the internet as a reference resource in teaching learners

has the immediate advantage of accessing vast information sources. The internet may also be used as a communication tool on social networks. When comparing the advantages and drawbacks of the internet as an educational tool, its advantages outweigh its drawbacks by far.

point out that searching for information in books or any other printed forms could be a thing of the past as information is readily available on the internet in electronic format.

Within a short space of time one can find valuable information, however this becomes impossible if there is no internet connection. There are several search engines that can be used by the learners. Teachers have emails where they communicate with other colleagues and parents regarding learner performance in mathematics and any other information that benefits the learner in mathematics. More information and other resources are uploaded on the D6 communicator where parents can play an active role of assisting their learners to learn mathematics at home.

> One participant pointed out that: "…*sometimes I upload extension work, past exam papers on the D6 communicator as it is a faster way to reach out to parents."*

Parents are willing to partner with teachers in assisting learners to understand mathematics and learners can work on these at home.

### 6.2.2 How are technology-based tools integrated in Mathematics classrooms?

Participants acknowledged the importance of integrating technology-based tools into teaching mathematics and described in detail how they use these tools in the classroom. Technology-based tools are used in various ways with the purpose of enhancing performance in mathematics.

> Orchid responded by saying: "…*effective teaching does not happen without preparation, before I present the lesson I do research work on the internet about the topic for that particular week, I look for suitable activities to explain the concept better and make sure that my lesson will reach every student in my class.*"

All participants alluded to the fact that teaching a lesson without preparation has loopholes hence it is appropriate that every teacher has a lesson plan. When classroom practitioners plan to integrate technology into a lesson they should consider the technology knowledge and mathematics content knowledge needed by learners and the best practices for teaching

mathematics concepts (Kafyulilo, Fisser, Pieters, & Voogt, 2015). Teachers have all the information at their fingertips as they have several resources on the internet. The web has a great possibility of enhancing student learning and is an effective teaching and learning tool. While it is a great learning tool, information from the web must be used carefully, as there is no screening or reviewing process. The teacher needs to get information that can be tailor-made to suit learners' needs.

The interactive boards are used to display learners' workbooks during the lesson.

> Lily pointed out that; "*…I have a hard and soft copy of NumberSense workbooks…the soft copy is displayed on the big screen, this is helpful as it becomes easy to catch their attention and allows me to highlight important vocabulary and concepts. Besides seeing the workbook on the screen, the colour of the pictures appeals to the learners' eyes.*"

Seeing pictures and colourful words on the screen increases the learners' attention as they do not easily get bored. Bester and Brand (2013) argue that without capturing learners' attention, maximum learning will not occur, and they also point out the importance of determining what appeals to different learners during a lesson, suggesting technology integration as an option. During the lesson the teacher may decide to project a picture from the workbook in a 2 Dimensional or 3 Dimensional format and some pictures are shown in motion accompanied by sound to catch the learners' interest which makes learning fun.

Participants shared that technology-based tools have made teaching mathematics more enjoyable as compared to the time they used traditional teaching methods. When students are engaged actively in the learning process, significant learner achievement can be noted as compared to the use of teacher-centred methods. The uses of the tools vary from one lesson to another (Ford, 2018).

### 6.2.3 Why are technology-based tools integrated in Mathematics classrooms?

Several reasons were given as to why these tools are made use of in mathematics classrooms in the Intermediate Phase. Learners learn better when they see, as such, technology-based tools allow learners to visualise different mathematical concepts. Most learners can be assisted in grasping concepts by delivering them in a practical and not theoretical form. Teaching with technology makes it easier for the teacher to access abstract topics which, if taught in an abstract manner, will not make much sense to the learners. For meaningful

learning to take place, learners should construct knowledge through cognitive processes required for problem-solving. It is a challenging task for learners to memorize facts by merely looking at them**.**

> Orchid stated; *"... learners find it easy to process concrete rather than abstract information and the interactive board is able to provide learners with concrete concepts if used well..."*

Technology - based tools such as the Interactive Whiteboard and the iPad are very useful in this regard.

Almost all learners are attracted to technology-based tools and what they offer therefore it is advantageous to use them in the classroom. This is shown in the following excerpts:

> Rose responded: "…*technology - based tools catch the learner's interest.*"
>
> Rose stated: "…*we catch them with what they like…concepts can be understood better… technology is inclusive of every learner in the classroom".*

Several participants highlighted that one of the reasons why technology is being used in mathematics classrooms is that it catches and stimulates the learners' attention, thereby making it easy for them to concentrate on the task at hand. If learners pay attention understanding of concepts becomes easier.

Furthermore, participants found it easier to explain mathematical concepts in a better way as technology-based tools can show images. Learners learn better when they touch, see and hear.

> Daisy stated: "…*the interactive board and the iPad show images which later on helps learners to easily remember the concept.*"

Other participants reiterated the same view about technology - based tools. Such tools have the ability to produce visual images and sound. Sound is especially helpful to auditory learners. Seeing visual images on interactive boards can stimulate learners' imagination thereby affecting cognitive levels to process information faster (Cole, 2006).

> Orchid pointed out that: "…*most learners spend their time watching television at home and it excites them. When they see pictures and images in an interactive board and hear sound through listening to mathematical videos, they feel like they are watching television. Learning occurs when they are relaxed".*

It is fun to learn through technology-based tools for many learners. The tools are not only being used by the learners for enjoyment but are further used to enhance the way in which they learn. Shelly (2008) argue that when technology-based tools are used in a suitable manner, they can enhance student achievement and assist them into meeting learning outcomes.

> In one of the excerpts, one participant pointed out that: "…*technology caters for learners with different learning needs.*"

A class is composed of learners with different learning styles, with each learner having a different way of absorbing, processing and retaining information. It is ideal that teachers understand this notion in order to choose appropriate instructional strategies. Promoting innovative instructional strategies will benefit some learners as they become active participants in the learning process. Constructivists' believe that learners form new knowledge through different social experiences hence teachers must provide learning environments where learners can freely share information.

> Lily pointed out that: *"…collaboration of learners in technological classrooms is very easy and beneficial."*

It is in technological classrooms where there is interaction and collaboration. Learners work together in groups while those who feel like working individually are not deprived of the opportunity to do so.

In the participating school, collaboration comes through giving projects and assignments where learners are assigned groups with whom to work. Small groups of less than five learners may be selected to work on a well-defined task independent of the teacher. These researchers further point out that, individual learners are held accountable for their own performance and the teacher only facilitates the group learning process.

Studies reveal that when learners collaborate and interact with each other, not only are their mathematical reasoning skills enhanced, but their expressive language is also developed. The researcher noted that in mathematics, technology offers a variety of activities which speak to different learning styles in their classrooms. These include kinaesthetic, tactile and auditory just to mention a few. Technology is for all learners, academically gifted or not.

With the use of the internet, teachers can now access abstract topics and present them in small but understandable concrete concepts which are visual and auditory (Rajpal, 2017).

One of the participants in the current study taught reading the grid in a very realistic and visual manner. Instead of drawing a grid, she asked the learners who had travelled in an aeroplane before to share their experiences. She guided them to talk about the seating arrangements, and later showed a colourful picture of an aeroplane on an interactive board and made learners choose their seats. In the process she made them identify their seat number. The lesson was enjoyed by learners as it related to their real-life situation and later they could read other grids with much more understanding.

In the next lesson the same participant played a video to introduce her lesson. The video was meant to consolidate what had been previously taught. The flexibility to pause the video was amazing as the participant could take time to further explain the concept. This showed how these technology-based tools can be used to the teachers' advantage and at the same time enhance learning. Furthermore, videos can be loaded on the learners' iPads for them to watch at home if there was not enough time to do it in the classroom. A video is regarded as an effective educational tool if the teacher considers the three components - managing the cognitive load with the video, promoting active learning with the video and maximizing student engagement with the video (Brame, 2016).

## 6.3 How is the current study beneficial to mathematics education?

The current study will be beneficial to the Department of Education, mathematics teachers, policy makers and stakeholders in the education system in different ways. The study has discussed the benefits of the use of technology-based tools in mathematics lessons as there are considered one of the innovative teaching methods used in the 21st century. It is imperative that traditional classrooms are transformed and made to accommodate today's learners who are technologically inclined. The teaching and learning environment is conducive to learner satisfaction as innovative classrooms are favourable to both the learner and the teacher. Improvement of learners' performance in mathematics is key in the Umlazi District, hence if these technology-based tools are integrated they will play a significant role in enhancing performance in the subject. Innovative strategies like integrating technology into mathematics lessons can help to arouse interest in learning and leaves learners wanting to learn more.

The use of these tools encourages collaboration between learners and peers and teachers and their colleagues. Learners work with their peers in solving problems, doing projects, making Power Point presentations while teachers work with one another sharing different activities

online. When learners are confident in solving problems in mathematics, the chances are that they will be able to solve complex problems later in life. Subject advisors from the Department of Education, Principals and Departmental Heads should make teachers aware of what technology brings into the classrooms and how mathematics can be taught better using these tools. In his study, Cole (2006) identified the following benefits of using the whiteboard. These included delivering and presenting lessons in an interactive form, collaboration of teachers and learners, sharing of resources through email, catering for learners with learning challenges and allowing learners and teachers to use functions that come with whiteboards such as highlighting, circling and erasing errors among other functions.

## 6.4 Recommendations

The researcher conducted a study about the integration of technology-based tools into mathematics classrooms within the Intermediate Phase. There is need for the Department of Education to speed up the process of providing schools with technology - based tools in order to reach the goal stated in the e-Education policy which states that, every child will be able to confidently and creatively use technology in order to develop skills and be active participants in the global community by 2013. The researcher noted that there are many schools which are not yet integrating these tools simply because they are not yet available. Providing schools with such tools must be made a priority and their use especially in mathematics be emphasised to make the subject enjoyable and easy to learn. Teachers need to be made aware of technology-based tools, be trained and supported in using these tools to meet this goal, and in the process support teaching and learning. Integrating these tools must begin in primary schools as learners are already exposed to cellular phones in their homes. They can learn with technology-based tools and their performance in mathematics can be improved.

South African schools have diverse environments; some schools do not have access to technology-based tools and some schools have technological resources and the capable personnel to use such resources. The Department of Education ought to find a way to provide for poor schools where there is lack of resources. Schools where technology-based tools are available should be encouraged to use them to benefit the learner in understanding mathematics instead of using them for preparation purposes only. Learners must also be allowed to use the tools in the learning process, for example, they should be provided with the internet to research different mathematical concepts. Primary school learners should be

taught to go beyond learning basic typing skills to aiding understanding of concepts. Currently, some teachers still do not fully understand the importance of integrating technology-based tools into teaching mathematics.

Coaching teachers on technology integration into mathematics lessons should begin from teacher training programs at colleges or universities in order to prepare teachers for this process. Research on technology integration shows the effects of teacher attitudes and their fears towards technology use as having negative effects on their integration. Teachers are also to be made aware of the positive contribution brought about by using technology- based tools in mathematics classrooms hence the need for shifting from common methods to innovative methods. Such innovative methods ensure that learners are fully engaged and partner with their teachers in their learning. There are several teachers who firmly believe in the traditional way of teaching mathematics, where the concepts are taught through the drill lecture methods. It is also vital that all stakeholders in the education system are made aware of what technology-based tools can offer in mathematics rather than seeing them as tools that cannot enter the classroom. For example, some teachers and parents still view cellular phones and iPads as bad tools that cannot be brought to school as they are believed to distract learners.

The researcher also recommends that mathematics subject advisors hold continuous workshops on teacher collaboration in using these tools in mathematics. This will assist all teachers as different ideas will be shared by many teachers to enhance mathematics performance.

## 6.5 Limitations

This study was confined to one school in an urban area. It then becomes difficult to generalize the results as this is an upmarket school that is well resourced and has been using technology-based tools for quite some time. It could have been ideal to conduct the study in different school settings, for example in urban, peri-urban and rural schools where one finds learners from different backgrounds which would have also led to more participants partaking in the study. Having participants from different backgrounds would have assisted the researcher with more information as they face different challenges and may sometimes view things differently. Results obtained from different contexts could have varied, thereby allowing for generalisation.

The researcher noted with concern that even in urban areas, there are schools with technology-based tools that are not fully utilised due to various reasons. In some schools, technology-based tools are being used, but teachers' busyness constrains them from assisting researchers with information. There are a few primary schools in Umlazi District which are currently integrating tools into their lessons, however these tools are mostly being used by teachers for other purposes like lesson preparation.

Another challenge was limited time to collect data as the researcher is employed on a full-time basis. This meant that permission had to be sought from the school management in order to conduct field work at the research site. Data collection time sometimes clashed with important activities at the participating school which led to the postponement of collecting data, affecting time granted by the researcher's employer.

## 6.6 Conclusion

The integration of technology-based tools in mathematics makes learning fun and interesting. Mathematics is found to be challenging by most learners hence teachers are to use innovative instructional methods which are appealing to learners. The use of technology-based tools catches the learners' attention through seeing colourful images, watching and listening to mathematical videos and playing games. According to the participants, learners never have enough of technology-based tools. As these tools are interesting to learn with, most learners grasp mathematical concepts without realising that they are tackling difficult concepts. Cox and Graham (2009) believe that effort and time invested in developing constructivist classrooms where innovative teaching methods are made use of will later show their great effectiveness in learner performance. He further points out that teachers upload assignments, projects, articles, games and pictures for learners which enable learners to learn at school and home in a creative manner. The teacher facilitates learning in various ways taking into consideration the needs of his / her learners. Technology-based tools enable the teacher to prepare activities that are aligned with mathematical concepts, assisting the student to learn with ease.

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# Appendices

1. Appendix A: Informed consent letter to the Principal
2. Appendix B: Informed consent letter from the participating school
3. Appendix C: Informed consent letter to the teachers
4. Appendix D: Informed consent letter to the parent
5. Appendix E: Informed consent letter to the learner
6. Appendix F: Questionnaires for teachers
7. Appendix G: Observation Schedule

8. Appendix H: Interview Schedule
9. Appendix I: Ethical Clearance
10. Appendix J: Turnitin Report
11. Appendix K: Letter from the editor

## Appendix A- Informed Consent letter to the School Principal


Dear Principal,

Name of School: Clifton College

**Re: Permission to conduct study at your school**

My name is Thobekile Mlilo, a female candidate studying at the University of KwaZulu-Natal, Edgewood Campus in Durban. I am requesting for permission to conduct a research at your school. The research study is entitled:

**Exploring the integration of technology-based tools in the Intermediate Mathematics Classrooms.**

I require Grade 4-6 Mathematics teachers to participate in this research. The teachers shall be required to respond to a questionnaire and take part in semi-structured interviews. The researcher will also request for the opportunity to observe Mathematics lessons that will demonstrate the integration of technology-based tools in intermediate phase classes.

All discussions including interviews will be audio/video recorded using a phone, and thereafter transcribed verbatim to produce transcriptions. The information gathered is required for the analysis of data and completion of the actual write up of the thesis. Collecting this information will take approximately five school weeks. Dates and times for data collection will be discussed and arranged with you at a later stage. The researcher will ensure that this takes place during mathematics teaching time, as per the school timetable to avoid disruption of lessons. Participation is completely voluntary and participants have the right to withdraw from this study at any time. They will not be penalized if they choose to do so. The information provided by the teachers will not be used against them and shall be strictly used for the purposes of research only. The information collected shall be treated with strict confidentiality and anonymity of participants shall be observed.
Participation in this study will not result in any cost to your school or the participants. Neither the participants nor the school will receive any financial remuneration for the participation of the students in the study. However costs incurred by participants as a result of their involvement in this project will be covered. This study does not intend to harm the participants in any way but merely seeks to contribute to teaching and learning of Mathematics in the Intermediate Phase. All participants will be handed letters of consent which they will have to carefully read and sign, before I begin data collection. Thank you in advance for your contribution to the research.

I may be contacted at:
Cellphone number : 0784626444
Email Address : thobesandile@gmail.com

For further information, please feel free to contact my supervisor who is located in Edgewood Campus of the University of KwaZulu-Natal

Supervisor's Name : Dr Jayaluxmi Naidoo
Phone Number : 031 260 1127
Email Address : naidooj2@ukzn.ac.za

You may also contact the Research Office through:
Ms P Ximba (HSSREC Research Office)
Tel: 031 260 3587
Email: ximbap@ukzn.ac.za)

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

Kind regards,
Thobekile Mlilo.

Student Number: 215082701

**Declaration**
I …… (Full name/s of School Principal) of …….. (Name of School), hereby confirm that I understand the contents of this document and nature of this research project. I consent / do not consent to the teachers and learners participating in this project. I also grant permission for the school to be used as the research site.

| | | | |
|---|---|---|---|
| YES | | NO | |

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

| | | | |
|---|---|---|---|
| YES | | NO | |

Signature of the School Principal Date

---------- ----------

SCHOOL STAMP

## Appendix B- Informed Consent letter from the participating school

one school one family

CLIFTON
Scholarship
Leadership
Sportsmanship
Community

2 February 2018

To whom it may concern

This letter serves to inform Kwa-Zulu Natal University, that Thobekile Mlilo, (Student Number -215082701) has been granted permission to do research at Clifton School in 2018. The proposed duration of data collection is 5 to 6 weeks.

The student will be permitted to collect data from the Intermediate Phase Mathematics classes (Grade 4 – 6).

Proposed topic: The integration of technology into Mathematics Lessons.

Yours faithfully

IVAN BONIASZCZUK
DEPUTY PRINCIPAL: ACADEMICS

CLIFTON SCHOOL NPC
CO. REG. NO. 2000/006079/08
NPO NO. 031-244
102 LAMBERT ROAD
DURBAN, 4001
TEL: 031 312 2147 FAX: 086 4637 275



# Appendix C - Informed Consent letter to the teachers


Dear Participant - Teacher,

My name is Thobekile Mlilo. I am a female candidate studying at the University of KwaZulu-Natal, Edgewood Campus, Durban. I am interested in integration of technology - based tools into Mathematics lessons in the Intermediate Phase. To gather the information, I am interested in asking you some questions and observing how you integrate technology based tools into Mathematics lessons.

The research study is entitled:

**Exploring the integration of technology-based tools in Intermediate Mathematics Classrooms.**

Please note that:

- Your confidentiality is guaranteed as your input will not be attributed to yu in person, but reported only as a population member opinion.
- Any information given cannot be used against you and collected data will be used for purposes of this research only.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- You have a choice to withdraw form participaing from the research project at any given time. You will not be penalised for taking such action.
- The interview may last for about 30 to 45 minutes and class observation will follow your school timetable
- Data collected will be stored in a secure storage and destroyed after 5 years.

Please indicate by ticking where applicable:

| EQUIPMENT | WILLING | NOT WILLING |
|---|---|---|
| Audio Equipment | | |
| Video Equipment | | |

I may be contacted at:
Cellphone number : 0784626444

Email Address : thobesandile@gmail.com

For further information, please feel free to contact my supervisor who is located in Edgewood Campus of the University of KwaZulu-Natal

Supervisor's Name : Dr Jayaluxmi Naidoo
Phone Number : 031 260 1127
Email Address : naidooj2@ukzn.ac.za

You may also contact the Research Office through:
Ms P Ximba (HSSREC Research Office)
Tel: 031 260 3587
Email: ximbap@ukzn.ac.za)

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

Kind regards,

Thobekile Mlilo.

Student Number: 215082701

Thank you for your contribution to this research

……

## Declaration

I ……. (Full name/s of participant) hereby confirm that I understand the contents of this document and the nature of the research project. I give consent/ do not give consent to participating in the project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Signature of participant: ……. Date :……

## Appendix D - Informed Consent to the Parent

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Dear Parent,

**INFORMED CONSENT LETTER**

My name is Thobekile Mlilo. I am a female candidate studying at the University of KwaZulu-Natal, Edgewood Campus, Durban. I am interested in integration of technology - based tools in Mathematics classrooms in the intermediate Phase. To gather information, I have to observe a Mathematics lesson in Grade _____where your child is in / part of. The research study is entitled:

**Exploring the integration of technology based tools in the Intermediate Mathematics Classrooms.**

Please note that:

- Your child's confidentiality is guaranteed. If ever any videos/pictures are taken during class observation they will be used for academic purposes. Pictures will always be blurred.
- Your child's involvement is purely for academic purposes only, and there are no financial benefits involved.
- You have a choice to allow your child to participate or not participate. You will not be penalised for taking such an action.

I may be contacted at:
Cellphone number : 0784626444
Email Address : thobesandile@gmail.com

For further information, please feel free to contact my supervisor who is located in Edgewood Campus of the University of KwaZulu-Natal

Supervisor's Name : Dr Jayaluxmi Naidoo
Phone Number : 031 260 1127
Email Address : naidooj2@ukzn.ac.za

You may also contact the Research Office through:
Ms P Ximba (HSSREC Research Office)
Tel: 031 260 3587
Email: ximbap@ukzn.ac.za)
If you grant permission for me to conduct this research, please complete and return the form below.

Kind regards,

Thobekile Mlilo.

Student Number: 215082701

Thank you for your contribution to this research

……

## Declaration

I,……. (Full name/s of parent) hereby confirm that I understand the contents of this document and the nature of the research project. I give consent/ do not give consent to my child participating in the project.

I understand that my child is at liberty to withdraw from the project at any time, should I so desire.

Signature of parent: ……. Date :……

## Appendix E- Informed Consent letter to the learner


Dear Participant - Learner,

**INFORMED CONSENT LETTER**

My name is Thobekile Mlilo. I am a female candidate studying at the University of KwaZulu-Natal, Edgewood Campus, Durban. I am interested in integration of technology - based tools in Mathematics classrooms in the intermediate Phase. To gather information, I have to observe a Mathematics lesson in Grade _____where there will be technology - based tools integration.

The research study is entitled:

**Exploring the integration of technology based tools in the Intermediate Mathematics Classrooms.**

Please note that:

- Your confidentiality is guaranteed. No names will be mentioned in the research.
- Data collected will used for purposes of this academic research only.
- You have a choice to participate or not participate in this research. You will not be penalised for taking such action.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- Audio and video equipment tools may be used during the lesson observed in order to collect accurate data.

I may be contacted at:
Cellphone number : 0784626444
Email Address : thobesandile@gmail.com

For further information, please feel free to contact my supervisor who is located in Edgewood Campus of the University of KwaZulu-Natal

Supervisor's Name : Dr Jayaluxmi Naidoo
Phone Number : 031 260 1127
Email Address : naidooj2@ukzn.ac.za

You may also contact the Research Office through:
Ms P Ximba (HSSREC Research Office)
Tel: 031 260 3587
Email: ximbap@ukzn.ac.za)

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

Kind regards,

Thobekile Mlilo.

Student Number: 215082701

Thank you for your contribution to this research.

## Declaration

I ……. hereby confirm that I understand the contents of this document and the nature of the research project. I give consent/ do not give consent to participating in the project.

I understand that my child is at liberty to withdraw from the project at any time, should I so desire.

Signature of a learner: ……. Date :……

## Appendix F - Questionnaire for teachers

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

To whom it may concern,

This is a questionnaire about the integration of technology - based tools in Mathematics classrooms. It seeks to understand which tools are being used in Mathematics classrooms, why and how are they used.
Kindly respond to the questions to the best of your knowledge. There are no right or wrong answers, opinions and information given in this questionnaire shall be solely for the purposes of this research.

Your contribution will be greatly appreciated.

Thank you,
Thobekile Mlilo (Researcher).

……

**Questionnaire**

**Instructions**

1. Please answer all questions.
2. For section A, kindly tick the appropriate box and for section B write your response in the spaces provided.

**Section A**

1. Please indicate your gender below

| | | | | | |
|---|---|---|---|---|---|
| Female | | Male | | Other | |

2. Please indicate your age-group

| 20 - 29 years | 30 - 39 years | 40 - 49 years | 50 - 59 years | 60 - 69 years | 70 - 79 years | Other |
|---|---|---|---|---|---|---|
| | | | | | | |

3. Please indicate the grade/s you teach below?

| Grade 4 | Grade 5 | Grade 6 | Other |
|---|---|---|---|
| | | | |

4. Please indicate all the subjects that you are currently teaching.

| Mathematics | Life-Skills | English | Social Sciences | Natural Sciences | Languages | Other |
|---|---|---|---|---|---|---|
| | | | | | | |

5. Is Mathematics your specialization?

| Yes | | No | |
|---|---|---|---|

6. Please indicate the number of years of teaching Mathematics.

| 0-5years | 6-10years | 11-15years | 16-20years | +20years |
|---|---|---|---|---|
| | | | | |

7. Have you been trained to integrate technology-based tools into Mathematics classroom?

| Yes | No | Other (specify) |
|---|---|---|
| | | |

8. Rate yourself on integrating technology-based tools into Mathematics lessons. (optional)

| Average | Good | Very Good | Other |
|---|---|---|---|
| | | | |

9. Are technology based tools used in Mathematics user friendly?

| Yes | No | To a certain extent | Other |
|---|---|---|---|
| | | | |

10. If your answer is no or to a certain extent, kindly write your reasons.

| |
|---|
| |

**Section B**

| Which technology-based tools are used in your Mathematics lesson? | Elaborate how you use the tools in teaching Mathematics | What are the reasons for using technology-based tools in your Mathematics lessons? |
|---|---|---|
| | | |
| | | |
| | | |

1. Do you have any special programs for teaching Mathematics? If yes, please list them on the lines provided.
   ……
   ……

2. What are the advantages/disadvantages of using these programs?
   ……
   ……

3. Are there any setbacks for integrating technology-based tools into Mathematics lessons?
   a) For learners
      ……
      ……
   b) For teachers
      ……
      ……

## Appendix G - Observation Schedule


The observation below seeks to answer the question – How do teachers integrate technology-based tools into Mathematics lessons?

The researcher will observe:

| |
|---|
| a) The classroom setting<br><br>b) Interactional setting |

| |
|---|
| 1) List of technology-based tools being integrated into Mathematics lessons.<br>…….. ……<br>…….. ……<br>…….. ……<br>……... ……<br>…….. ……<br><br>2) What is the focus of observation?<br>3) Which mathematical concept is being taught?<br>4) Observe if there are any rules governing the use of technology-based tools.<br>5) How long does the use of tools take place in each lesson?<br>6) Is there any participation from learners?<br>7) Check the type of tasks given to learners.<br>8) How does the teacher assist struggling learners?<br>9) Was learning differentiated or collaborative?<br>10) Did learners understand the concept being taught?<br>11) Check how classroom control is done.<br>12) Was the teacher able to use the tools effectively?<br>13) Were learners also using the tools? If yes, how and what did they use them for?<br>14) Did any type of assessment take place? |

| The researcher will also observe |
|---|
| |

| When is the tool integrated? | Name of the technology tool. | How is the technology tool integrated into the lesson? |
|---|---|---|
| a) Lesson introduction | | |
| b) Developing the concept | | |
| c) Showing steps in working out a method | | |
| d) Concluding a lesson | | |
| e) Throughout the lesson | | |

## Appendix H - Interview Questions


**Interview Questions**

1. Does integration of technology-based tools impact teaching and learning in Mathematics? Elaborate your answer.

| |
|---|
| |

2. Which technology-based tools do you use in Mathematics classrooms?

| |
|---|
| |

3. Are there any challenges in integrating technology-based tools in Mathematics lessons?

| |
|---|
| |

4. What challenges are faced by learners in learning Mathematics through the integration of technology-based tools?

| |
|---|
| |

5. Do you undergo training regularly to enhance your skills in the use of technology-based tools?

| |
|---|
| |

6. As new programs are introduced from time to time, how do you keep abreast of the new changes?

| |
|---|
| |

7. In your opinion, how does use of technology-based tools enhance performance? Substantiate your answer.

| |
|---|
| |

8. If you were to compare the traditional way of teaching Mathematics and use of technology-based tools in Mathematics, which method would you promote? Explain your answer.

9. Should integration of technology-based tools be a requirement in all Primary School Mathematics classrooms? Give reasons for your answer.

10. Given an opportunity, what would you like to share with other teachers regarding integrating technology-based tools in Mathematics classrooms?

11. What support do you get from the Department of Education with regards to integration of technology-based tools in Mathematics?

## Appendix I – Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

14 February 2018

**Mrs Thobekile Milio 215082702**
**School of Education**
**Edgewood Campus**

**Dear Mrs Milio**

**Protocol reference number: HSS/0109/018M**
**Project title: Exploring the integration of Technology based tools in Intermediate Mathematics Classrooms**

**Full Approval – Expedited Application**

In response to your application received 8 February 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

**Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.**

**PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.**

**The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.**

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....

**Dr Shamila Naidoo (Deputy Chair)**
**Humanities & Social Sciences Research Ethics Committee**

**/pm**

cc Supervisor: Dr Jayaluxmi Naidoo
cc Academic Leader Research: Dr SB Khoza
cc. School Administrator: Ms Tyzer Khumalo

**Humanities & Social Sciences Research Ethics Committee**
**Professor Shenuka Singh (Chair)**
**Westville Campus, Govan Mbeki Building**
**Postal Address:** Private Bag X54001, Durban 4000
**Telephone:** +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** [illegible] / [illegible] / [illegible]
**Website:** www.ukzn.ac.za

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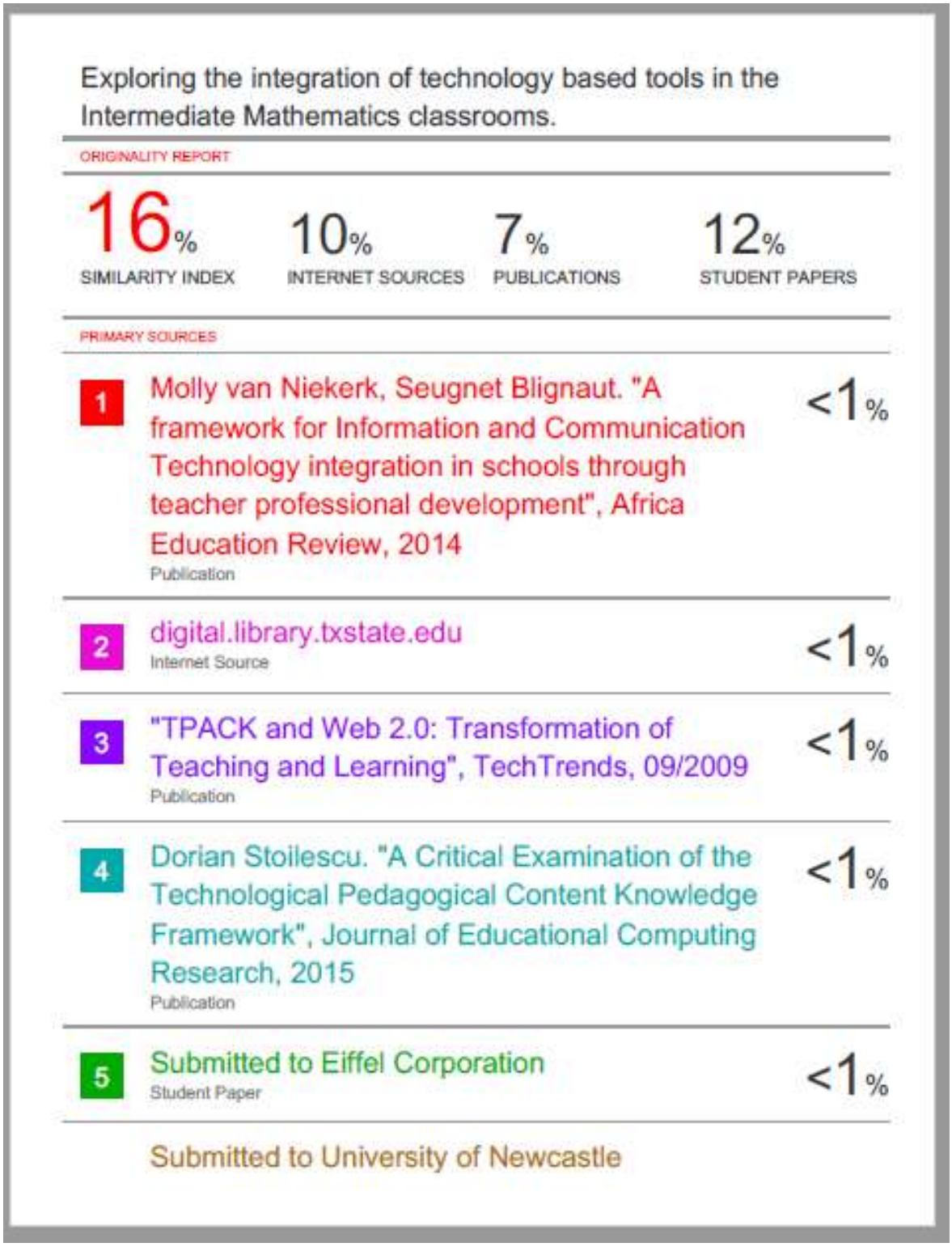
# Appendix J– Turnitin Report



Exploring the integration of technology based tools in the Intermediate Mathematics classrooms.

ORIGINALITY REPORT

| 16% | 10% | 7% | 12% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Molly van Niekerk, Seugnet Blignaut. "A framework for Information and Communication Technology integration in schools through teacher professional development", Africa Education Review, 2014<br>Publication | <1% |
| 2 | digital.library.txstate.edu<br>Internet Source | <1% |
| 3 | "TPACK and Web 2.0: Transformation of Teaching and Learning", TechTrends, 09/2009<br>Publication | <1% |
| 4 | Dorian Stoilescu. "A Critical Examination of the Technological Pedagogical Content Knowledge Framework", Journal of Educational Computing Research, 2015<br>Publication | <1% |
| 5 | Submitted to Eiffel Corporation<br>Student Paper | <1% |

Submitted to University of Newcastle

## Appendix K – Editing Letter

# Angela Bryan & Associates

6 Martin Crescent
Westville

Date: 04 November 2019

To whom it may concern

This is to certify that the Dissertation: Exploring the Integration of Technology-Based Tools in the Intermediate Mathematics Classroom written by Thobekile Mlilo has been edited by me for language.

Please contact me should you require any further information.

Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312