THE VIABILITY OF TEACHING AND LEARNING MATHEMATICS USING INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) IN GAUTENG PAPERLESS CLASSROOMS

A thesis submitted in fulfilment of the requirements of the degree of

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ABSTRACT

It is widely accepted that the integration of Information and Communication Technologies (ICTs) in teaching and learning presents innovative ways to enhance the face-to-face classroom experience. However, an erroneous belief often exists amongst policy makers and other stakeholders in education that the mere provision of ICTs will automatically enhance teaching and learning and have a positive influence on learners' academic performance. What they fail to realise is that for technology to be beneficial, it must be integrated pedagogically with understanding. The literature indicates that South African teachers are not using technology optimally but rather to replicate the traditional chalkboard or whiteboard-based way of teaching. The South African government has invested substantial funds into providing ICTs to schools. Its most recent project is that of "paperless schools" established at selected sites in Gauteng. Paperless classrooms are a new phenomenon internationally and the literature indicates that there are different connotations associated with this term. However, the MEC of the Gauteng Department of Education (GDE), Panyaza Lesufi maintained that in Gauteng Paperless Schools, teaching and learning would take place solely with the use of technology and exclude the use of the chalkboard, pen, and paper. Considering that South Africa is plagued with various challenges such as load-shedding as well as the lack of technological skills on the part of both teachers and learners, the question arises as to how teaching and learning can be constructed in a paperless context. This study focused on the viability of teaching and learning Mathematics in a paperless classroom, and is underpinned by the TPACK (Technological, Pedagogical and Content Knowledge) conceptual framework. It employs a qualitative, multiple case study methodology. Data were collected using semi-structured, in-depth face-to-face interviews, focus group discussions, and classroom observations of Mathematics lessons. The findings reveal that despite paperless classrooms being established in 2015, Mathematics is still being taught in a blended environment, contrary to what the Gauteng MEC expected. In addition, most of the teachers are using the smartboard simply as a replacement for the chalkboard and the tablet solely to access electronic copies of the textbook. Teachers and learners prefer a blended teaching and learning environment and believe that Mathematics cannot be taught solely with ICTs. The study concludes that there are too many factors that contribute to the non-viability of teaching and learning Mathematics in a paperless context to make this viable in current circumstances. Furthermore, the propensity amongst teachers seems

to be to resist a full-scale move to an entirely paperless classroom environment, and instead continue to develop the blended learning space with both digital and non-digital media and technologies.

Key Words: ICTs; Technology; TPACK; Paperless Classroom; Viability; Mathematics; Blended learning

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DEDICATION

This thesis is dedicated to my two children

AAQILAH AND ZAID MINTY

and my dearest and loving husband

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Thank you for being my pillars of support during this time. This degree would not have been achievable without your encouragement and constant patience with me.

DECLARATION

I, Rehana Minty, declare that the work depicted in this thesis is original (except where citations and acknowledgements indicate otherwise). No part of this work has been or will be submitted in any form as part of another degree at this, or any other University.

Rehana Minty

2020

Table of Contents

ABSTRACT....ii
PUBLICATIONS....iv
ACKNOWLEDGEMENTS....v
DEDICATION....vi
DECLARATION....vii
LIST OF FIGURES....xiii
LIST OF TABLES....xiv
APPENDICES....xvi
LIST OF ACRONYMS....xvii
CHAPTER ONE....1
OVERVIEW OF THE STUDY....1
Introduction and Background to the Study....1
ICTs and Technology....3
Paperless Classrooms....3
The Concept Viability....4
The Pedagogic Integration of ICTs....5
Mathematics as a Subject in South African Schools....6
ICTs as a Means to Improve Teaching and Learning....7
Challenges Encountered with the Pedagogic Integration of ICTs in South African Schools....8
Requisite Skills for the Integration of ICTs in the Classroom....9
The Socio-Economic Status of South African Learners....12
The Rationale for this Study....12
Research Problem....13
Research Questions....14
The Aim of the Study....14
Objectives of the Study....15
The Conceptual Framework for this Study....15
Methodology....16
Participants for the Study....16
Methods of Data Collection....17
Data Analysis....17
Validation of the Findings....17
Thesis Layout....17

Summary 19
CHAPTER TWO 20
THE CONCEPTUAL FRAMEWORK 20
Introduction 20
The TPACK Conceptual Framework 20
TPACK in the Teaching and Learning of Mathematics 26
Summary 32
CHAPTER THREE 33
LITERATURE REVIEW 33
Introduction 33
ICTs in Teaching and Learning 36
Factors that Contribute Towards the Successful Integration of ICTs 39
Factors that Inhibit the Incorporation of ICTs in Teaching and Learning 42
Subject Content as an Inhibitor to ICT Integration 46
Teacher Workload 48
Teachers' and Learners' ICT Knowledge, Skills and Competence 48
Lack of Confidence to Use ICTs in Teaching and Learning 50
Teachers' Resistance to Change 50
A Lack of Technical and Pedagogical Support to Integrate ICTs in Teaching and Learning 52
The Lack of Time to Incorporate ICTs in Teaching and Learning 53
Parents' Involvement with Learning 53
Cheating, Plagiarism and Impersonation 56
Lack of ICT Policies 57
Teaching Styles 58
Blended Teaching and Learning Environment 62
The Pedagogic Integration of ICTs in Mathematics 64
Assessment in Mathematics 67
The Viability of Teaching and Learning in Paperless Classrooms 70
Summary 74
CHAPTER FOUR 77
THE RESEARCH DESIGN AND METHODOLOGY 77
Introduction 77
A Comparison of the Quantitative and Qualitative Methods 77
The Research Design 80
Case Study Research 81

Research Sites 83
Gaining Access to Sites 83
Ilungelo Secondary School 84
Iziphethu Secondary School 85
Isilomo Secondary School 87
Intaba Secondary School 88
Research Strategies, Selection of Participants and Research Participants 90
Data Collection Methods 92
Semi-Structured In-Depth Face-to-Face Interviews 92
Focus Group Discussions 94
Classroom Observations 98
Data Analysis Procedures 99
Open Coding 101
Axial Coding 102
Selective Coding 102
Software Tools for the Analysis of Qualitative Data 103
Ensuring Authenticity of the Study 105
Ethical Considerations 108
Summary 109
CHAPTER FIVE 110
FINDINGS AND DISCUSSION 110
PART 1: GAUTENG MEC'S STATEMENT ON PAPERLESS SCHOOLS AND THE CONTEXT OF PAPERLESS CLASSROOMS 110
Introduction 110
"It was a political statement" 112
"Most of the kids that go to Maths Lit … have given up on Maths" 118
"[In a] paperless class … you don't use paper, purely rely on ICTs." 121
"Reducing the maximum of paper" 124
"It's not really paperless" 126
"I would definitely prefer it, to teach in a blended environment" 135
Summary 143
CHAPTER SIX 145
FINDINGS AND DISCUSSION 145
PART 2: CHALLENGES REGARDING THE INTEGRATION OF ICTS IN THE TEACHING AND LEARNING OF MATHEMATICS 145
Introduction 145

"Even now lots of classes the smartboard doesn't work" 146
"It just gets frozen… that is when now you start stammering." 147
"If there's no electricity everything will be shut down" 150
"For two years we have been off-line in terms of Wi-Fi" 152
"They stole about 200 tablets at the Harry Gwala Centre" 155
"They are not using those tablets for educational purposes" 159
"The screen that they are even using, it's too small" 163
"The district wants on paper" 166
"I think we do need training, more intense training" 171
"No, the school does not support us" 179
Summary 184
CHAPTER SEVEN 186
FINDINGS AND DISCUSSION 186
PART 3: THE QUESTION OF VIABILITY 186
Introduction 186
"I don't think we can go hundred percent paperless" 187
"Mathematics should stay solely on paper" 193
"Some of the topics you cannot use technology alone" 196
"Writing tests or exams using the tablet is not possible" 199
"Honestly with paper, it's easier" 204
"We don't have adequate skills to use technology" 206
"My technology skills aren't that good" 210
"They were very resistant to change" 213
"My teaching style … is modelled by the learners that I teach" 216
"When you write something, you remember it" 219
"Sometimes parents will want to, but they can't afford" 221
"It's a total distraction to students" 224
Summary 228
CHAPTER EIGHT 230
CONCLUSIONS, CONTRIBUTIONS OF THE STUDY, LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH 230
Introduction 230
Conclusion 1: Mathematics is NOT being taught in a "paperless" context 231
Conclusion 2: Teachers prefer to teach Mathematics and learners prefer to learn Mathematics in a blended environment 234
Conclusion 3: GDE requirements contradict a paperless context 235

Conclusion 4: The use of tablets to teach and learn Mathematics does not at this stage appear to be viable 236
Conclusion 5: Teachers and learners lack technological skills 236
Conclusion 6: Teachers and learners require continuous training and support 237
Conclusion 7: The current infrastructure presents problems for a paperless environment 238
Conclusion 8: Theft and damaged technological devices impedes teaching and learning 238
Conclusion 9: Learners use the tablet to access the textbook and the internet only 239
Conclusion 10: All Mathematical content cannot be taught solely using technology 239
Conclusion 11: The use of technology is unsuitable to assess Mathematical content 240
Conclusion 12: Marking of assessments using a tablet is difficult 241
Conclusion 13: The socio-economic status of the school and learners, as well as social factors, are detrimental to teaching and learning in a paperless context 242
Conclusion 14: The disadvantages of technology-use impedes learning in a paperless environment 243
Conclusion 15: Teachers' attitudes to a paperless environment 243
Contributions of this Study 244
Limitations of the study 244
Recommendations for future research 246
Summary 246
LIST OF REFERENCES 249
APPENDICES 264

LIST OF FIGURES

Figure 2.1 The TPACK framework and Knowledge components from http://tpack.org/ 21
Figure 2.2 Four Central Components of Mathematics-Related TPACK and their Derivation from Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK) (Guerrero, 2010, p. 134).....26

Figure 3.1 Concept map indicating relationships between learning environment entities and external entities.....433
Figure 3.2 Internal and External Factors Affecting ICT Integration in Education (Albugami & Ahmed, 2015, p. 42) 44
Figure 3.3 Three Teaching Styles (Thornton, 2013).....60
Figure 3.4 Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001, p. 1).....688

Figure 4.1 Data Analysis – Search Patterns in Data (Adapted from Neuman, 2000, p.426) 1011
Figure 4.2 The Research Design Summarised (Adapted from Saunders, Lewis & Thronhill, 2012, p. 160) 1055

Figure 5.1 Themes on MEC's Statement on Paperless Schools 11010

Figure 6.1 Sub-themes for Challenges.....1455

Figure 7.1 Themes on Viability 1866

Figure 8.1 Factors that Contribute to the Non-Viability of Teaching and Learning Mathematics in a Paperless Environment 2311

LIST OF TABLES

Table 2.1 Description of the different types of knowledge in the TPACK framework together with examples (Adapted from Mishra & Koehler, 2006 in George, 2014, p. 56 and Chai, Koh, & Tsai, 2013, p. 33) 25
Table 2.2 Questions to Guide the Development and Use of Technology by Analysing Each Component of TPACK (Adapted from Guerrero, 2010, p. 138) 29

Table 3.1 Five teaching styles (Adapted from Grasha, 1994, p. 143) 599

Table 4.1 Verifying Authenticity in a Qualitative Study (Adapted from Pather, 2005)..... 107

Table 5.1 Teachers Opinions of the MECs Statement on Paperless Schools 1111
Table 5.2 Understanding of the Concept ‘Paperless’ Environment..... 1211
Table 5.3 Misunderstanding of the Concept "Paperless” Environment..... 1233
Table 5.4 The Current Situation in so-called “Paperless” Schools..... 1255
Table 5.5 Teachers’ and Learners’ Preference for the Learning Environment..... 1322

Table 6.1 Smartboard not Working 1466
Table 6.2 Smartboard and Tablets Freeze..... 1477
Table 6.3 Electricity Outages..... 14949
Table 6.4 Unavailability of Wi-Fi..... 1521
Table 6.5 Broken, Stolen or Lost tablets..... 1543
Table 6.6 The Inappropriate Use of Technology 15857
Table 6.7 The Unsuitability of Tablets and One Smartboard for Teaching and Learning 1622
Table 6.8 GDE Requirements..... 1655
Table 6.9 Inadequate Training 1688
Table 6.10 Inadequate Support 1788

Table 7.1 Teachers’ Opinions on Viability..... 1877
Table 7.2 Learners’ Opinions on Viability 1922
Table 7.3 Mathematical Content..... 1966

Table 7.4 Assessment in Mathematics 1988
Table 7.5 Marking of Assessments 2033
Table 7.6 Teachers' Technological Skills 2066
Table 7.7 Learners' Technological Skills 21010
Table 7.8 Teachers' Attitudes to a Paperless Environment 2133
Table 7.9 Teaching Styles 2166
Table 7.10 Learning Preference: Technology vs. Paper-based 2188
Table 7.11 Socio-Economic Status of Learners and Schools 22020
Table 7.12 Disadvantages of Technology-Use 2244

APPENDICES

Appendix A: Consent letters

Appendix B: Ethical Clearance

Appendix C: Interview Schedule (Teachers)

Appendix D: Focus Group Discussion Schedule (Learners)

Appendix E: Classroom Observation

LIST OF ACRONYMS

AMTE	Association of Mathematics Teacher Educators
BBT	Born before Technology
BODMAS	Bracket, Of, Division, Multiplication, Addition, Subtraction
BYOD	Bring your own device
CAQDAS	Computer Assisted Qualitative Data Analysis Software
CK	Content Knowledge
DGS	Dynamic Geometry Software
DoE	Department of Education
FITness	Fluency of Information Technology
GDE	Gauteng Department of Education
HEI	Higher Education Institution
HoD	Head of Department
IBM	International Business Machines
ICT	Information and Communication Technology
ICTs	Information and Communication Technologies
IEB	Independent Examination Board
LMS	Learning Management System
MEC	Member of Executive Council
NBTs	National benchmarking Tests
NDE	National Department of Education
NECC	National Educational Computing Conference
NRC	National Research Council
OECD	Organization for Economic Cooperation and fDevelopment
OLPC	One laptop Per Child
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SD	Secure Digital
SGB	School Governing Body

TCK	Technological Content Knowledge
TK	Technological Knowledge
TPACK	Technological Pedagogical and Content Knowledge
TPCK	Technological Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
USA	United States of America
USB	Universal Serial Bus
Wi-Fi	Wireless computing network
WISE	World Innovation Summit for Education

CHAPTER ONE

OVERVIEW OF THE STUDY

Introduction and Background to the Study

This study investigated the viability of teaching and learning Mathematics using Information and Communication Technologies (ICTs) in paperless classrooms at selected schools in Gauteng, South Africa. The Gauteng Member of Executive Council (hereinafter referred to as the Gauteng MEC), Mr Phanyaza Lesufi, anticipated that the use of ICTs in the classroom would raise the standards of teaching and learning to that of international levels. Consequently, the Gauteng Department of Education (GDE) launched a project known as "paperless schools" at specific sites in 2015, to be completed by 2018. However, the intention to go paperless may be confronted with several challenges as discovered in this study and will be presented later in Chapter Six.

Technology has become an integral element of life in the 21st century both globally and locally and is a powerful tool that may be used to support the education process. When used appropriately, technology could become an effective teaching and learning tool. ICTs have the potential to change the current situation in classrooms to be more learner-focused and collaborative rather than being teacher-centred and reliant on the use of textbooks. However, there is an assumption that the mere provision of ICTs to learners and its presence in the classroom may automatically transform the classroom context, a myth that many people, including policy makers in education, fall prey to. In numerous studies, it has been suggested that accessibility to technological devices does not necessarily imply an improvement in learners' results (Courtney, 2017; House, 2010 in Cheema & Zhang, 2013; Cheung & Slavin, 2013; Balanskat, Blamire & Kefala, 2006; Wozney, Venkatesh & Abrami, 2006; Cuban, 2001). In fact, it is the combination of a teacher's ICT knowledge, skills, and pedagogical knowledge that may contribute to learners' achieving academic success. This could be the result of the teacher's TPACK (Technological, Pedagogical and Content Knowledge) that would enable them to decide when, how, and which technology to use to enhance the teaching and learning experience.

Cuban (2001) stated that policy makers in the United States of America (USA) appear to base their policy notions upon assumptions about the integration of ICTs in education, as is evident in the following concluding statement at a National Education summit meeting held at IBM (International Business Machines) headquarters in 1996:

> *We are convinced that technology, if applied thoughtfully and well-integrated into the curriculum, can be utilised as a helpful tool to assist student learning, provide access to valuable information and ensure a competitive edge for our workforce* (Cuban, 2001, p. 16).

However, teachers, who are expected to integrate ICTs in teaching and learning, were under-represented at this summit, rather than being the majority. The delegates at the summit were convinced that ICTs could be useful during student life to prepare them for the workplace. However, the delegates provided no evidence to support their conviction and consequently, this assumption appeared to be idealistic, begging the question: *What would the delegates gain from promoting the use of ICTs in education*?

In addition, during President Clinton's term of office, he highlighted four goals for the integration of ICTs in schools in the USA. These were; to ensure availability of technology in all schools, connectivity from one classroom to another and the world, the integration of educational software into the curriculum, and teacher readiness to incorporate ICTs in education. In Cuban's (2001) opinion, policy makers tend to make assumptions that once the first two goals have been achieved, the last two goals would inevitably be realised. It is apparent that the decision of policy makers in the USA regarding the use of ICTs in education was influenced by these erroneous assumptions. Education policy makers in South Africa are no different since they share similar beliefs and trust that the provision of ICTs at schools will have a positive influence on teaching and learning. This is evident in the Gauteng Province annual education performance plan of 2015/2016 that states:

> *… responding to new educational imperatives for quality learning, we will work towards introducing smart paperless classrooms to ensure that all learners and teachers have progressive access to broadband and innovative learning and teaching tools which will enable learners to meaningfully participate in the economies of the future… To bring education into the 21st century, the Department is rolling out the digital classroom of the future. This classroom with be fitted with hi-tech technology that will improve the quality of teaching and learning in the province* (Gauteng Department of Education, 2015, p. 3).

The Gauteng Province annual education performance plan for 2016/2017 reiterates "*The GDE e-education strategy will use technology to improve education outcomes especially learner achievement and attainment*" (Gauteng Department of Education, 2016, p. 47). Therefore, to

keep abreast with international trends regarding the use of ICTs in education, the South African Government allocated funds for this project and the training of teachers in ICT skills. However, these projects have not been as successful as the Government had anticipated for several reasons. To name a few; there were problems with internet connectivity and to exacerbate the problem, teachers lacked the requisite pedagogic skills to integrate ICTs (Minty & Pather, 2014; Chigona & Chigona, 2010). Despite not having achieved the anticipated goals to successfully integrate ICTs in the classroom, the GDE embarked upon a new project, which was establishing paperless schools in 2015. Being a qualified former Mathematics teacher with reservations as to whether Mathematics could be taught in a paperless environment, I realised that this would be a valuable study to conduct. Therefore, this study focused on the viability of teaching and learning Mathematics using ICTs in a paperless classroom. At the onset, it is essential to provide an account of the following concepts "*ICTs and technology*", "*paperless classrooms*" and "*viability*" that are used throughout this thesis.

ICTs and Technology

According to Rouse (2019), "… *although there is no single, universal definition of ICT, the term is generally accepted to mean all devices, networking components, applications and systems that combined allow people and organizations… to interact in the digital world*". Therefore, the terms ICTs and technology are used interchangeably in this thesis and refer to digital technologies that are used in education to transform the educational process.

Paperless Classrooms

The term paperless classroom is often conflated with classrooms that incorporate ICTs in teaching and learning and where pen and paper are still in use. It is, therefore, necessary to clarify what constitutes a paperless classroom and relate this to the MEC's expectations regarding teaching and learning in a paperless context. A paperless classroom may be described as:

> *… just that…paperless. It is not only the effort but the successful integration of technology in the classroom that eliminates all purposes of paper, ink, clutter … Instead, this classroom will be completely cloud-based. Students will be able to access their lessons, homework, and grades solely through the internet or school network* (Creating a Paperless Classroom, n.d.).

The use of the phrase "*eliminates all purposes of paper, ink*" in the above description is indicative that pen and paper and the chalk, chalkboard, or whiteboard, that are major

components of the traditional classroom context, would no longer be in existence nor used. This is precisely what the MEC envisaged for Gauteng paperless schools, which was evident in his statement to the press, "*Tomorrow morning in this school, we are officially burying the chalkboard, we are officially burying the duster, we are officially burying the chalk. Gone are the days when they have to write in exercise books and hand in the assignment*" (Falanga, 2015). The above statement by the Gauteng MEC is pertinent and central to this study since he categorically stated that teaching and learning in a paperless environment would eliminate the use of pen and paper and the chalk and chalkboard. This This meant that teaching and learning in a paperless environment would take place exclusively with the use of technology, which corresponds with the description of a paperless classroom as provided above. It was important to be certain what the Gauteng MEC meant by a paperless environment so as not to ascribe individual assumptions on what a paperless environment, entails. Having discussed the concept of a "paperless classroom", it is necessary to discuss the concept of viability as this concept was central to this study.

The Concept Viability

The word viability originates from the Latin root "*vita"* which means "*life*". Consequently, the notion viability[1] refers to the ability of something to live and grow as well as possessing the attributes of having the possibility of succeeding. In the teaching environment, the question that emanates is "*How would one establish whether an idea is viable or not?*", in this case, teaching and learning Mathematics in a paperless environment. With research, experience, and pedagogical principles, the viability of teaching and learning Mathematics in a paperless classroom, was determined. It was necessary for teachers from the identified schools to consider operational and pedagogic viability. Pedagogic viability refers to a teacher's ability to teach successfully in a paperless context, which includes the ability to apply sound pedagogic principles as well as technical expertise in teaching. This notion of viability was theorised by me in the context of this study as there is a dearth of literature on the "the pedagogical viability of ICTs".

Operational viability consists of several components. However, for this study, the focus was on technical viability; that is, *would these schools be able to achieve the outcomes as*

[1] https://www.vocabulary.com/dictionary/viability

anticipated by the Gauteng MEC regarding teaching and learning in a paperless context? Since this was the focus of the study, the concept viability may be interpreted as the potential for paperless classrooms to flourish and be sustained. In addition, this study sought to investigate whether teachers had the requisite technological skills that are crucial to teach successfully in a paperless context, further elucidating the viability of a paperless context for the teaching and learning of Mathematics. If other projects in South African schools involving the pedagogic integration of ICTs have not achieved the anticipated outcomes, *what are the chances of paperless classrooms succeeding and being sustained?* To determine the answers to the questions posed in this section, it is important to discuss the pedagogic integration of ICTs.

The Pedagogic Integration of ICTs

Although learners of the 21st century may have become adept users of technology, teachers are required to ensure that the use of technology is underpinned by specific pedagogical knowledge and skills, as the combination of technology and poor pedagogy may worsen mediocre teaching. The successful pedagogic integration of ICTs requires teachers to envisage this change from the traditional teaching methods, to adapt the teaching and learning material and their teaching strategies to include technology. Teachers should be aware that effective pedagogy is key to the mediation and facilitation of learning. They should ensure that the use of ICTs does not merely reproduce or replicate the face-to-face classroom-based setting but rather introduces a transformed approach to teaching and learning. In a paperless environment, this shift from the traditional paper-based system to a completely electronic one, would require teachers to re-think how the teacher, learners and the material would interrelate with each other both within and outside the classroom (Runnels & Rutson-Griffiths, 2013).

Dillon and Morris (1996 in Kler, 2014) claimed that teachers may readily accept the pedagogic integration of ICTs, if the use of such technology was consistent with their current pedagogic practices and beliefs. In addition, if the selected ICTs were not complicated to use and offered advantages to teaching and learning, it would increase the degree of ICT integration. The literature on the use of ICTs in teaching and learning indicated that despite teachers' lack of ICT skills, the commitment to the integration of ICTs was high because these teachers believed that a knowledge of ICTs was significant for the learners' future (Cuban, 2001; Mumtaz, 2000).

Research conducted in Europe found a lack of technical and pedagogical support to be serious inhibitors of the use of ICTs in the Mathematics and Science classrooms (European Schoolnet, 2013). Likewise, studies conducted at selected schools in South Africa, showed that a lack of competent and effective technical support discouraged teachers' pedagogic integration of ICTs (Chigona, Chigona & Davids, 2014; Minty, 2011). What may be inferred from the above discussion is that for the pedagogic integration of ICTs, the availability of good technical support is a prerequisite (Kler, 2014). Furthermore, to be motivated to integrate ICTs in teaching and learning, teachers must have the requisite subject content knowledge and realise the importance of integrating ICTs (Minty & Pather, 2014; Chigona & Chigona, 2010; Ainley, Eveleigh, Freeman & O'Malley, 2010; Lau & Sim, 2008). Considering that this study focused on the viability of the pedagogic integration of ICTs in Mathematics in a paperless environment, it was essential to discuss Mathematics as a subject in South African schools.

Mathematics as a Subject in South African Schools

In South African schools, learners find Mathematics as a subject, to be a challenge. In Grade 10, learners choose subjects, which they will study for the next three years, leading to their final examination in Grade 12. The National Department of Education (NDE) believes that Mathematical skills are a necessity and therefore, offer learners an alternative subject, Mathematical Literacy[2] instead of Mathematics. With learners performing poorly in Mathematics, the Gauteng MEC is of the opinion that the use of ICTs would arouse learners' interest, encouraging them to choose Mathematics instead of Mathematical Literacy (Magubane, 2015). However, this assumption on the part of the Gauteng MEC that learners would be encouraged to choose Mathematics instead of Mathematical Literacy because they would use technology, is not convincing enough and there is no evidence to justify his claim. As a former Mathematics teacher, I experienced learners' resistance to choosing Mathematics as a subject for the following reasons; *dislike of the subject, fear of the difficulty and complexity of Mathematics, not requiring the subject for further studies and fear of failure*. Consequently, assuming that learners would choose Mathematics instead of Mathematical Literacy, solely on

[2] "Mathematical Literacy provides learners with an awareness and understanding of the role that Mathematics plays in the modern world. Mathematical Literacy is a subject driven by life-related applications of Mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday situations and to solve problems" (Department of Education, 2003, p. 19)

the use of ICTs in teaching and learning, is a flawed assumption. Considerable research has been conducted both globally and locally on the integration of ICTs to improve teaching and learning, this is discussed next.

ICTs as a Means to Improve Teaching and Learning

The Malaysian Government anticipated that teaching and learning would improve with the use of ICTs as all Malaysians, irrespective of whether in rural or urban schools, would be exposed to the same opportunities regarding ICT development and implementation (Aziz & Shah, 2015). Similarly in Turkey, a project known as the "FATIH[3] project" aimed to support equal opportunities in education in an attempt to enhance the effective use of technology in teaching and learning by supplying tablets and interactive whiteboards to schools (Karatas & Tutak, 2015). Like the Malaysian Government and the FATIH project, the Gauteng MEC stated that he wants "… *to radicalise education in the township[4] so that they can compete with any other learner*" and that "…*township pupils should not suffer because of where they live*" (Falanga, 2015). Consequently, the GDE deemed it necessary to provide free tablets to all rural and township schools that obtained a hundred percent pass rate in the Grade 12 examinations in 2014. However, the mere provision of the latest technology to schools cannot be necessarily associated with the quality of education, improving.

The Gauteng MEC's rationale to provide schools with technology, was that schools in Gauteng would become paperless and that teaching, and learning would take place solely with the use of technology. This begged the following questions: *Was the Gauteng MEC not being premature and over-ambitious regarding paperless classrooms? Was there no place for the chalkboard and chalk, pen and paper any longer?* Despite the MEC's optimism about paperless classrooms, the question was: *Why should one get rid of the pen and paper when its use was still valued by both educators and learners?* Warlick (2014, p. 1) claimed; "… *we need*

[3] Increasing Opportunities and Improvement of Technology Movement

[4] "The term "township" has no formal definition but is commonly understood to refer to the underdeveloped, usually (but not only) urban, residential areas that during Apartheid were reserved for non-whites (Africans, Coloureds and Indians) who lived near or worked in areas that were designated 'white only' (under the Black Communities Development Act (Section 33) and Proclamation R293 of 1962, Proclamation R154 of 1983 and GN R1886 of 1990 in Trust Areas, National Home lands and Independent States)." (Pernegger & Godehart, 2007, p. 3)

technology in every classroom and in every student's and teacher's hand because it is the pen and paper of our time … it is the lens through which we experience much of our world". What may be inferred from the above statement is that ICTs are a necessary tool for the 21st century, however, at no point, does Warlick (2014) imply that we needed to discard the pen and paper that were used in the traditional classroom.

A teacher from the USA (Pilane, 2015), who used tablets in the Mathematics classroom, argued that in the case of Mathematics, the focus was not on the final answer but on how the learner arrived at the answer. Although there are sketchpads available on a tablet, she did not believe that the use of the tablet could replace the pen or pencil in Mathematics because she wanted to see the steps that led to either the correct or the incorrect answer so that she could assist the learner (Pilane, 2015). Considering that access to technology was not the same in all schools in South Africa as well as taking into account the diverse challenges experienced regarding the use of technology in teaching and learning, *was it feasible to "bury" the chalk, the duster and not to use exercise books?* It is important at this point to discuss the challenges experienced with the pedagogic integration of ICTs in South African schools.

Challenges Encountered with the Pedagogic Integration of ICTs in South African Schools

Helen Zille, the former leader of the Democratic Alliance, pointed out that there was a need in South Africa for twenty-one thousand new teachers a year, however, only five thousand graduated per annum (Zille, 2009). She also stated that of these five thousand qualified teachers, only fifteen percent were appropriately qualified Mathematics teachers. Even though there was a shortage of appropriately qualified Mathematics teachers, and despite lacking the relevant qualifications, they were appointed to teach the subject. The problem regarding the shortage of qualified Mathematics teachers in South Africa persists because four years later after Zille's (2009) publication, another newspaper article stated that although twenty-five thousand teachers qualify each year, there remains a shortfall of fifteen thousand teachers, specifically in subjects like Mathematics, Science and Technology (Mtshali, 2013). In addition, "*… at a national level, only 26% of teachers have basic ICT skills and only 7% have intermediate skills in using ICTs for teaching and learning, according to the department of basic education*" (Alfreds, 2016). It is apparent from the above discussion that it is imperative

for South Africa to produce more and better qualified Mathematics teachers. In addition, it is necessary to train teachers on how to integrate ICTs in their specific disciplines, to benefit learners. Furthermore, before attempting to convert all classrooms in Gauteng to paperless environments, it was incumbent upon the Gauteng MEC to take cognisance of the above-mentioned problems, because these challenges would be impediments to teaching and learning using ICTs irrespective of the context within which teaching and learning is constructed.

A study conducted by Vilakati (2014) that aimed at determining the percentage of South African Science and Mathematics teachers who experienced the integration of ICTs and pedagogical skills as an obstacle, found that 55% of these teachers lacked ICT-related skills and 62% lacked pedagogical skills. The conceptual framework developed by Mishra and Koehler (2006) raised questions regarding the technological and pedagogical knowledge, and the skills that teachers needed to have to integrate ICTs successfully in the classroom. However, there is no clarity as to what technological and pedagogical requirements are necessary for Mathematics teachers to integrate ICTs in teaching and learning successfully. In addition, there is a dearth of literature pertaining to the requisite technological and pedagogical knowledge and the skills that teachers should possess to successfully integrate ICTs in the Mathematics classroom. Consequently, this study was a necessity as the intention was to convert all Gauteng classrooms to a paperless context.

The Gauteng MEC was keen to transform classrooms into paperless environments, however, if teachers lacked the relevant Mathematical content knowledge as well as the expertise to integrate technology in their pedagogy, this would inhibit the successful transition to a paperless context and, consequently, the viability of paperless classrooms became questionable. It was, therefore, important that the GDE ensured that teachers had the requisite pedagogical and technological knowledge and the skills to incorporate ICTs in the teaching and learning of Mathematics.

Requisite Skills for the Integration of ICTs in the Classroom

The use of technology in teaching and learning offers unprecedented ways to enhance the education process. However, for this to happen, it is crucial that teachers receive the relevant training for the pedagogic integration of ICTs. This training should not focus on the mere

acquisition of basic computer literacy skills but should concentrate on teachers acquiring the requisite skills to use the selected technology and software to teach the content of a specific discipline. This was evident in a study conducted by Tatar (2013) of preservice Mathematics teachers on the use of software to teach Mathematics. The findings highlighted that the participants in this study were equipped with only basic computer skills using Microsoft Word, Excel and PowerPoint, which they had learned during their undergraduate studies at university. The participants found that these skills were inadequate to use the available software to teach Mathematics; there were no courses offered at the university that focused specifically on how to use software to teach the subject content. For the integration of technology to have a positive influence on teaching and learning, it should be used in such a manner that it challenges learners' higher-order thinking skills instead of a medium through which content knowledge is simply communicated to learners.

"Teaching Teachers for the Future" was an example of training initiated by the Australian Commonwealth Government, which aimed at improving the use of ICTs in teacher education. One of the initiatives of this project was to transform a University Mathematics unit for preservice teachers that focused on improving the use of ICTs for teaching and learning. An important outcome of this study was that preservice teachers found that when they were introduced to and were allowed to explore the use of software, they became familiar with it. This led to increased confidence levels regarding the use of such software for teaching and learning. The teachers believed that such an in-depth examination of the specific software would promote the integration of ICTs in the classroom. In addition, they maintained that they were not confident to use software that had only been demonstrated to them (Bate, Day & Macnish, 2013). This was evidence that it was necessary for teachers to be trained to use the specific software and technology that they are expected to use in the classroom to provide a quality learning experience (Karatas & Tutak, 2015; Bate et al., 2013; Tatar, 2013).

However, the GDE's ICT and e-Education Integration strategy focused specifically on training teachers to use the technological device (Gauteng Department of Education, 2016). What was apparent was the emphasis on the training of teachers to use the devices without any mention of training on the specific software for their specific disciplines. Although it was necessary for teachers to know how the device worked, it was just as important for teachers to be trained to use the specific software that the GDE would disseminate to schools for the integration of ICTs

in the classroom. Perhaps this in-depth training on how to use the requisite technology and software may have assisted teachers to enhance the learning process; a study conducted by Ndlovu and Lawrence (2012) found that teachers in South African schools used technology to merely convey subject content rather than improve the learning experience.

Likewise, to benefit the learners, they should be trained to use technology for learning. Since there exists a symbiotic relationship between teachers and learners regarding the use of ICTs, it was necessary for both teachers and learners to have the requisite ICT and software skills. To teach Mathematics successfully in a paperless environment, it was important that all learners had similar ICT skills to cope with the various components of Mathematics. In an ideal situation, the above could work, however, in a typical classroom comprising learners with diverse abilities both in Mathematics and ICTs, a paperless environment may not be viable. However, if all learners are computer literate, then the task of using technology in the classroom becomes a simpler process but this is apparently contrary to the situation in most South African schools.

Research conducted by Batchelor (2014) with first-year students at a Higher Education Institution (HEI), regarding students' use of computers at South African schools, revealed that 47% of the students used computers for the first time at the HEI that they attended. In addition, 57% of the students indicated that their teachers at high school had not used technology in their teaching. The following questions were pertinent regarding teachers' non-use of technology: *Was it because the school lacked ICTs or did the teachers and learners not have the requisite skills to use the technology? Was it also possible that internet connectivity might have been a problem? Could teachers' attitudes and beliefs regarding the pedagogic integration of ICTs have influenced their use of ICTs in their classrooms? Could it also be possible that all students differed in their ICT skill-levels because this diversity in ICT competence could impede the use of technology in teaching and learning?*

The findings from my Master's research at selected high schools in Ekurhuleni, Gauteng, elicited reasons why teachers did not make substantial use of ICTs in their classrooms. These reasons were; the unavailability of technology, the age of the teacher, insufficient technical support, lack of confidence to use the available technology, and fear of learners being more competent with technology than they were (Minty, 2011). Furthermore, if both teachers and

learners were not skilled to use the technology and software for teaching and learning, this could lead to teacher frustration as it would disrupt the smooth flow of the lesson and consequently, the teacher may choose not to integrate technology (Warlick, 2014). In addition, learners who had access to a computer at home displayed higher levels of competence and confidence regarding its use (Cuban, 2001). The challenges identified above are still prevalent in South African classrooms, therefore, the question was, "*How would it be possible for these teachers to teach in a paperless environment*?" Considering the above-mentioned discussion and the socio-economic situation of many South African learners, uncertainty surrounds the viability of paperless classrooms.

The Socio-Economic Status of South African Learners

South African learners come from diverse socio-economic backgrounds and poverty is still prevalent irrespective of where learners reside. Poverty has an impact on the lives of learners; for example, parents may not be able to afford electricity in their homes, some learners live in informal settlements and nutrition is lacking, child-headed homes are a reality and high crime rates prevail. All the above-mentioned would inadvertently impede a learner's ability to use technology optimally. The GDE considered the needs of both township and rural schools and decided to provide tablets to those that achieved a hundred percent pass rate in the matric (grade 12) examinations in 2014. However, it was necessary to question whether they had considered the various issues that could inhibit the successful use of technology such as the availability of electricity, good network coverage and connectivity to the internet as well as reliable technical support, to mention but a few. A lack of technical support and poor internet connectivity would lead to teacher frustration and consequently, discourage teachers from integrating technology in their teaching and learning (Türel & Johnson, 2012). This being the case, *how then would paperless classrooms be viable?* The rationale for conducting this study is presented next.

The Rationale for this Study

I was intrigued by the MEC's confidence that all schools in Gauteng would be paperless by the year 2018. Being passionate about the teaching and learning of Mathematics, I was curious to examine how Mathematics could be taught in a paperless classroom. ICTs may not be suitable to teach all subject content and the use of ICTs is dependent upon the aims of teaching and

learning (Howard, Chan & Caputi, 2015; Ainley et al., 2010; Cuban, 2001). If all subject content could not be taught using ICTs, the viability of teaching and learning Mathematics in a paperless classroom was questionable.

In addition, given the statistics mentioned earlier, it was doubtful whether all classrooms in Gauteng would operate optimally in a paperless context as envisaged by the Gauteng MEC, as many teachers lacked the requisite ICT skills. Consequently, based on my trepidation regarding paperless classrooms, it was necessary to conduct a study of this nature. Moreover, since teachers are the most important component in the classroom, this study aimed to investigate whether teachers believed that they were sufficiently competent and confident to teach without the use of pen and paper, as these have been used successfully in the teaching and learning of Mathematics throughout the ages.

Pen and paper are affordable and easily attainable, whereas technology is expensive and is accompanied by additional costs, a few of which are; electricity costs, connectivity costs, device insurance, and repair costs. In the event of the device being damaged, it would have to be repaired during which time the learner would be left without a device. However, if technology as well as pen and paper was used to teach Mathematics in a blended environment, the learner would not be disadvantaged if they did not have a technological device. Therefore, conducting a study of this nature would elicit information on how teachers were able to continue with teaching and learning under such constraints. The research problem below emanated from the above-mentioned rationale.

Research Problem

The problem faced by South African schools persists with a lack of qualified Mathematics teachers, who do not have the pedagogical knowledge and ICT skills to integrate these in the teaching and learning of Mathematics. Teachers who do not have the requisite ICT skills and knowledge and may not have been trained to use the relevant software to teach Mathematics, exacerbate the problem of teaching in a paperless context. This study, therefore, attempted to answer the research questions mentioned below.

Research Questions

The central research question originated from the problems identified above.

What is the viability of teaching and learning Mathematics in a paperless classroom?

The following sub-questions assisted in answering the main research question.

- What are the requisite ICT skills for both teachers and learners to integrate ICTs in the teaching and learning of Mathematics?
- What are teachers' and learners' attitudes and opinions regarding the use of ICTs to teaching and learning Mathematics in a paperless classroom?
- How do teachers and learners experience the teaching and learning of Mathematics in a paperless classroom?

An expectation was that the above sub-questions could provide information pertaining to the ICT skills and practices on the part of Mathematics teachers and learners. In addition, the attitudes and opinions of teachers and learners regarding teaching and learning in a paperless context, was important to establish viability. Another significant aspect to consider viability was the authentic experiences of both teachers and learners, who have attempted to work in paperless classrooms. The aim of the study is presented next.

The Aim of the Study

This study aimed to investigate whether a paperless context for the teaching and learning of Mathematics was viable. In addition, teachers' attitudes, and their technological knowledge and skills regarding the integration of ICTs in the teaching and learning of Mathematics, was examined. Since learners are the recipients of teaching and are an important facet of education, it was also necessary to examine their expectations, experiences and attitudes towards learning Mathematics in a paperless context. To achieve the aim of the study, it was necessary to formulate objectives, which are presented next.

Objectives of the Study

The following objectives assisted in achieving the aim of the study.

- To examine the literature on the experiences of teachers and learners, both internationally and locally, towards the use of technology in the teaching and learning of Mathematics.
- To observe the teaching of Mathematics lessons in schools identified as being paperless schools.
- To examine through semi-structured in-depth face-to-face interviews, the opinions, experiences and attitudes of teachers, who use technology to teach Mathematics in schools identified as paperless.
- To investigate through focus group discussions, the expectations, experiences as well as the attitudes of learners towards learning Mathematics in a paperless context.

All the above objectives were underpinned by the TPACK conceptual framework to elicit the requisite information. A brief discussion to indicate the importance of the TPACK conceptual framework is presented below.

The Conceptual Framework for this Study

Maxwell (2005, p. 33) described a conceptual framework as follows; "… *concepts, assumptions, expectations, beliefs, and theories that supports and informs your research*". Consequently, the conceptual framework that was used for this study was Mishra and Koehler's (2006) TPACK framework (previously known as TPCK), which they considered essential for the effective integration of digital technology in teaching and learning. TPACK was valuable because it provided a conceptual framework that informed and directed research regarding the pedagogical integration of ICTs (Angeli & Valanides, 2009). Mishra and Koehler's (2006) TPACK framework drew on Shulman's (1986) construct of pedagogical content knowledge (PCK) to include the knowledge of technology.

For successful teaching using digital technology, the TPACK framework is indispensable. This framework describes three major components of teacher knowledge; technology, pedagogy, and content. These were used to investigate the pedagogical methods and technical proficiency

of teachers with regards to the integration of ICTs in the teaching and learning of Mathematics in a paperless context. When attempting to arrange for the classroom observations of Mathematics lessons, I was confronted with some resistance from the teachers to take part in the study at one site. Although appointments were confirmed, I was turned away on more than one occasion after arriving at the site. The teachers from this site claimed that they were not informed of the classroom observations to be held on that day, despite the Mathematics head of department alleged differently. Therefore, for this study, it was assumed that teachers had the requisite Mathematical content knowledge as all the teachers included in this study were qualified to teach Mathematics and the data collected focused primarily on the pedagogical and technological components of the TPACK framework. This framework will be discussed in greater detail in Chapter Two.

Methodology

A qualitative multiple case study was conducted at four selected sites that were identified as paperless schools. The qualitative research design was most appropriate as qualitative researchers study phenomena in their natural settings to view, understand and interrogate social phenomena such as interactions and the way participants behave (Creswell, 2014). This was a multiple case study conducted at three GDE schools intended to be paperless schools by the Department of Education (DoE), and one private school that intended to become a paperless school to keep abreast of teaching and learning trends using technology. At the time of the data collection, the private school was affiliated to the GDE, however, they were in the process of registering the school with the Independent Examination Board (IEB).

Participants for the Study

Participants in this study were Mathematics' teachers and learners. However, during the visit to schools, I realised that pertinent data could be collected from other members, even though they were not directly involved with the teaching and learning of Mathematics. As a result, these additional participants were included in the study.

Methods of Data Collection

This study comprised twenty interviews; sixteen were conducted with Mathematics teachers, three with staff members who belonged to the ICT committee, and one with a member of the Harry Gwala support team that was available at two of the research sites. Additionally, eight focus group discussions were conducted with Mathematics learners from the participating cases. Classroom observations, which formed the third part of the data collection process, were conducted to establish how Mathematics was taught and how the learners managed in a paperless context.

Data Analysis

Data from the interviews and focus group discussions were recorded in digital format and subsequently transcribed. Thereafter, the data were analysed using thematic analysis. A more in-depth explanation of the analysis of the collected data can be found in Chapter Four.

Validation of the Findings

The final step in a qualitative study includes authenticating the findings of the study to enhance its reliability so that similar results should be produced if the study were to be replicated. A detailed description of the methodology used for this study is in Chapter Four. It is important that the reader be provided with an outline of this thesis, therefore, a description of the thesis layout follows.

Thesis Layout

This thesis comprises eight chapters. A description of the thesis layout is presented below.

Chapter One introduced the study to the reader and provided information on the purpose of conducting a study of this nature. The rationale for this study and the main research question and sub-questions were identified. The aim and objectives followed, and the methodology used in this study was discussed. The main concepts of this study were also presented.

Chapter Two provides a discussion on the TPACK conceptual framework by Mishra and Koehler (2006), that underpinned this study.

Chapter Three discusses both international and local literature that was sourced.

Chapter Four provides an in-depth discussion of the qualitative method that was used. A multiple case study design was chosen since four cases were identified. An in-depth discussion of employing multiple case studies and my rationale for the choice of this method of investigation is also provided.

Chapter Five initially presents a discussion of the MEC's statement regarding paperless schools as well as Mathematics teachers' and learners' opinions of this. In addition, evidence of the understanding and the misunderstanding of the concept "paperless environment" is discussed. The situation as it exists in these paperless schools is presented and finally, teachers' and learners' preferences of the teaching and learning environment for Mathematics is highlighted.

Chapter Six presents the major challenges encountered by both Mathematics' teachers and learners at the four sites. Technology was problematic in that the smartboards would stop working or freeze at any time and some were not in working order. An additional problem was electricity outages, which interrupted teaching and learning. The unavailability of Wi-Fi was mentioned as well as learners' broken, stolen or lost tablets. Furthermore, some learners did not use the tablets for the intended purpose. Although teachers were attempting to incorporate ICTs in teaching and learning, the GDE insisted on hardcopies of all learners' work, learners' assessments and teachers' reports. Many of the teachers complained that their training was inadequate and that they did not have support.

Chapter Seven answers the question of the viability of teaching and learning Mathematics in a paperless context and begins with teachers' and learners' opinions on the viability of teaching and learning Mathematics in such an environment. In addition, this chapter presents a discussion on whether all Mathematical content lends itself or not to the sole use of technology. An explanation of assessments and marking of assessments using technology in Mathematics follows. Subsequently, teachers' and learners' technological skills are discussed. In addition, teachers' attitudes emerged as a relevantly strong theme. Both teachers and learners identified the socio-economic status of numerous learners as a major challenge to incorporating

technology in teaching and learning. Finally, the disadvantages of the use of technology were elucidated.

Chapter Eight presents the conclusions emanating from the findings, the contributions and limitations of the study and the recommendations for further research.

Summary

In this chapter, I have communicated the background, the rationale for the study, the research problem and questions, and the aims and objectives of this study. The important concepts that were central to this study, were clarified. A brief description of the TPACK conceptual framework that underpinned this study, followed. The methodology used was discussed, and the layout of the thesis and what could be expected in each of the upcoming chapters, was provided.

The next chapter presents a discussion on the TPACK conceptual framework that underpinned this study.

CHAPTER TWO

THE CONCEPTUAL FRAMEWORK

Introduction

This study was underpinned by the TPACK framework (previously known as TPCK), which stands for technological pedagogical and content knowledge, developed by Koehler and Mishra in 2006 and revised in 2009. This framework was applicable for this study as teachers in Gauteng schools are expected to teach in a paperless context. Studies using Mishra and Koehler's (2006) conceptual framework have been sourced both internationally and locally and provide the foundation for this chapter. The concepts that were pertinent to this study, which were "paperless classrooms" and "viability", have been discussed in Chapter One. However, it is important to reiterate that a paperless classroom is devoid of the use of pen and paper and the concept "viability" refers to the possibility of paperless classrooms being sustainable in the future. A discussion of the TPACK conceptual framework follows.

The TPACK Conceptual Framework

When using traditional technologies such as the blackboard and overhead projectors, the knowledge teachers acquired as preservice teachers were sufficient to teach the specific subject content and did not require modification of their teaching methods. This is because the traditional technologies such as the blackboard and the overhead projector performed a single function, this function remained constant over a period of time and the technologies were simple to understand and use. However, Mishra and Koehler (2006) pointed out that an additional type of knowledge, known as technological knowledge, which is an extension of Shulman's (1986) pedagogical content knowledge (PCK) framework, was essential. It should be combined with pedagogical knowledge, as well as content knowledge, to effectively incorporate digital technologies to teach a specific topic. It must be emphasised that the functionality of recent digital technologies does not remain constant. Teachers are therefore, required to transform their methods of teaching and adapt their teaching styles continuously to integrate technology in the classroom.

To re-emphasise, as the MEC anticipated that all Gauteng classrooms would be paperless by 2018, this raised the question of the viability of teaching and learning in a paperless

environment. The viability of teaching and learning in a paperless context would, therefore, depend on the teacher's ability to take cognisance of the relationship between technology, pedagogy and content, as well as the implementation of appropriate strategies, when integrating digital technologies in such a context. Koehler, Mishra and Yahya (2007) advocate that:

> *At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context-specific, strategies and representations.*

Technology integration is described as complex because it emanates from an understanding of the strong relationship between the three components, and the complicated way they are used in a complex and changing classroom environment (see Fig. 2.1 below). TPACK encompasses the incorporation of *"... knowledge of student learning, knowledge of the subject matter, and increasingly, knowledge of technology*", known as Pedagogic Knowledge (PK), Content Knowledge (CK) and Technology Knowledge (TK) (Mishra, Koehler & Henriksen, 2011, p. 23). The intersection of the three knowledge areas, which are content, technology and pedagogy, gives rise to a new type of knowledge known as technological pedagogical and content knowledge (TPACK) that is a requisite for teachers to effectively integrate technology in teaching and learning.

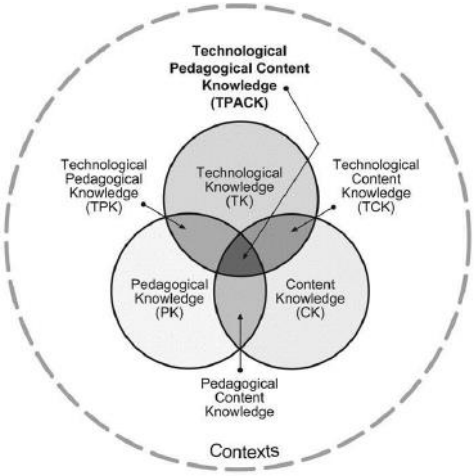

Figure 2.1 The TPACK framework and knowledge components from http://tpack.org/

CK refers to teachers' knowledge about the subject matter, in this case, Mathematics, which is either learned or taught. Consequently, CK is essential for teachers, which in Shulman's opinion would include knowledge of "… *concepts, theories, ideas, organizational frameworks,*

knowledge of evidence and proof, as well as established practices and approaches towards developing such knowledge" (Koehler & Mishra, 2009, p. 63). The implication is that for teachers to teach the specific subject content they should comprehend the arcane knowledge and rudiments of their respective teaching disciplines and be able to employ the diverse teaching strategies to communicate this knowledge to learners. Therefore, "… *teachers need to have developed an integrated knowledge structure that incorporates knowledge about subject matter, learners, pedagogy, curriculum, and schools; they need to have developed a pedagogical content knowledge, or PCK, for teaching their subjects"* (Niess, 2006, p. 196). However, once technology is integrated into teaching and learning, it is crucial for teachers to acquire "*... overarching conception of their subject matter with respect to technology and what it means to teach with technology – technology pedagogical content knowledge (TPCK)*" (Niess, 2005, p. 510).

It is, therefore, important that teachers have a comprehensive knowledge of the subject matter (Mathematical content), knowledge of the diverse teaching and learning strategies (the pedagogy) and the knowledge and skills of the technology to be used. Just possessing these knowledge domains as separate entities are of little consequence and benefit, if teachers do not know and understand how these should be combined to teach the Mathematical concepts in such a manner that these are comprehended by their learners. In addition, teachers should continuously strive to advance this knowledge either through research or professional development, to enhance their teaching (Tshuma, 2016). In this study, the focus was on the teaching and learning of Mathematics in a paperless environment, which would include a knowledge of Mathematical concepts, theories, Mathematical methods and evidence-based reasoning. Not having a sound foundation of Mathematical content knowledge could inhibit sound learning as well as learners having misunderstandings of the content area (Pfundt, & Duit, 2000 in Koehler & Mishra, 2009). To reiterate, for this study, it was assumed that teachers had the requisite Mathematical content knowledge as this was deemed to be a sensitive area. I believed that some participants may not have been comfortable if their content knowledge was being investigated, and as a result may not have consented to participate in this study.

PK refers to a teacher's comprehensive knowledge of teaching methods to create a teaching and learning environment that is effective for their learners. This, in essence, requires teachers to plan on how to deliver the content effectively, to provide a learning environment where

learners can work at their own pace to acquire this new knowledge or skills, as well as the use of appropriate assessment methods to evaluate individual learning. Using such an approach exposes learners to a learning environment that is more effective and enjoyable instead of a "one-size-fits-all" approach. Tshuma (2016) added that teachers need to ensure they have a curriculum plan, which comprises both pedagogy and content, before deciding which technology to use and how to integrate the selected technology into the course. This is essential since a curriculum plan embodies the teacher's philosophical view, the knowledge of the field or discipline and the methods to be used to teach and assess this knowledge.

It is difficult to characterise TK because it is constantly changing, whereas pedagogy and content knowledge are relatively stable. The Fluency of Information Technology (FITness) as suggested by the Committee of Information Technology Literacy of the National Research Council (NRC, 1999 in Koehler & Mishra, 2009) is the closest that can be found to describe TK, which states that FITness extends further than conventional computer literacy. This implies that individuals must have a deeper comprehension of information technology to use it effectively in their lives. In addition, individuals must realise that digital technology may help or hinder the attainment of aims and should be aware that since the functionality of digital technology changes rapidly, they would be required to adapt their teaching styles to these changes. It is, therefore, important to understand how digital technology influences practice as well as the knowledge of a particular discipline to create suitable technological tools to be used in education. In the case of Mathematics, TK refers to teachers' knowledge of the available technologies to teach the Mathematical content. There are various technologies to teach Mathematics, such as the calculator, spreadsheets, GeoGebra, Geometer's Sketchpad and the smartboard, just to name a few. It is important that teachers have a comprehensive knowledge of the technologies they choose to implement in the classroom as this knowledge may influence learning either negatively or positively.

Although digital technology could limit potential representations, it could also afford the creation of innovative and more diverse representations. Consequently, TCK may be described as a comprehension of how digital technology and content influence or limit each other. The use of technologies to teach and learn Mathematics transforms the Mathematical content that is being presented to learners. Spangenberg (2017) provided three examples of how the use of technology changes the learning environment. Firstly, when using dynamic geometry software

(DGS) in Mathematics, the classroom environment is transformed into a laboratory context, where learners engage with Mathematical concepts in an empirical milieu. Secondly, the use of graphing handheld technologies provides learners with various illustrations of Mathematical relationships. Finally, the use of spreadsheets in Mathematics allows learners to easily work with larger volumes of data that are more complex; a process that would be extremely difficult if learners had to complete such a task using pen and paper. It is, therefore, important that teachers understand which digital technologies would be appropriate to present specific content in Mathematics and which are not. In addition, it is important to point out that it is the subject content that needs to be taught that determines the choice of digital technology to be used and not vice versa.

Teachers must select the appropriate pedagogy to communicate knowledge and skills about a particular subject matter in such a way that learners can comprehend, retain and use the knowledge and skills when necessary. This is referred to as PCK, as the teacher uses their interpretation of the subject content to be learned, to select the most appropriate method to disseminate this knowledge and skills to learners. According to Shulman (1986), PCK included two components, the first being the most suitable method to teach the selected topic in a discipline and secondly, a comprehension of what factors constrain or assist in the learning of these concepts, which makes learning these either an easy or an arduous task for learners (Shulman, 1986). Therefore, teachers are "… *expected to process and evaluate new knowledge relevant for their core professional practice and to regularly update their knowledge base to improve their practice and to meet new teaching demands*" (Guerriero, 2014, p. 3). A teacher, who has a comprehensive understanding of PK, will know how learners construct knowledge and attain skills. Consequently, a comprehension of cognitive, social and developmental theories of learning is a requisite for PK.

PCK encompasses the fundamental principles of "… *teaching, learning, curriculum assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy*" (Koehler & Mishra, 2009, p. 64). In addition, PCK includes knowledge of erroneous beliefs and how they are approached. The significance of making connections among diverse content-based notions, learners' prior knowledge, diverse teaching methods, and adaptability as a result of examining other ways of approaching the same notion and challenges, are all necessary for teaching to be effective (Koehler & Mishra, 2009).

TPCK/TPACK refers to teachers' knowledge on how to teach specific content, in this case, Mathematics, using technologies that would support learners' diverse abilities and preferences (Spangenberg, 2017). This means that teachers need to know how to use the specific Mathematical technologies optimally in the classroom to reap the benefits that these, offer. The above discussion on the seven components of the TPACK framework is summarised in Table 2.1 below.

Table 2.1 Description of the different types of knowledge in the TPACK framework together with examples (Adapted from Mishra & Koehler, 2006 in George, 2014, p. 56 and Chai, Koh, & Tsai, 2013, p. 33)

TPACK Constructs	Explanation	Example
TK	Knowledge about the different ICT hardware and software that is available and how to use them. This knowledge can range from low-tech technologies, such as pen and paper, to digital technologies such as the internet, Web 2.0 tools and others.	In the case of Mathematics, these would include the knowledge and skills to use specific Mathematical software such as GeoGebra, MatLab, Maple and others.
PK	Generic knowledge about the methods of teaching and learning as well as classroom management techniques, preparation of lessons and assessment of learners' understanding without reference to the subject content.	Knowledge of the diverse teaching methods: lecture, heuristic, demonstration, inductive, deductive, analytic, project, problem-solving.
CK	Knowledge of the subject content that the teacher is required to teach without any consideration of how it should be taught.	Knowledge of Mathematical content
PCK	Knowledge relating to the teaching of particular concepts or topics, which includes how the knowledge is organised and the best way to teach that concept or topic. PCK combines both pedagogy and content with the aim of developing better teaching practices.	Learners often confuse the application of BODMAS rules. The teacher could use various Mathematics examples to illustrate the application of this rule taking into account the various misconceptions.
TCK	This refers to teachers' knowledge of how the use of technology could create new representations for specific content taking into account the affordances and constraints imposed by the use of technology.	Knowledge about specific ICT tools used to teach specific topics in Mathematics e.g. Geometer's Sketchpad or GeoGebra.
TPK	Refers to teacher's knowledge about how they can use various technologies to teach specific content and "… *knowing how teaching might change as a result of using particular technologies*" (Mishra & Koehler, 2006, p. 1028).	Knowledge on the use of ICTs as cognitive tools.
TPACK	Knowledge of the subject content combined with the most appropriate pedagogical strategies to address any misconceptions that may be related to the topic as well as knowledge of which ICT to integrate to teach the topic.	How to use GeoGebra to enhance learners' Mathematical knowledge and skills on graphs.

TPACK in the Teaching and Learning of Mathematics

As explained earlier in this chapter, TPACK is essential for the teaching and learning of Mathematics with technology. It is, therefore, important that Mathematics' teachers have sufficient expert knowledge to make informed decisions regarding their pedagogical choice in their selection of suitable technology to teach the Mathematical content. According to Guerrero (2010, p. 134) Mathematics' teachers' TPACK can be classified into four key areas (see Fig. 2.2 below): *Conception and use of technology, Technology-based classroom management, technology-based Mathematics instruction* and *depth and breadth of content.*

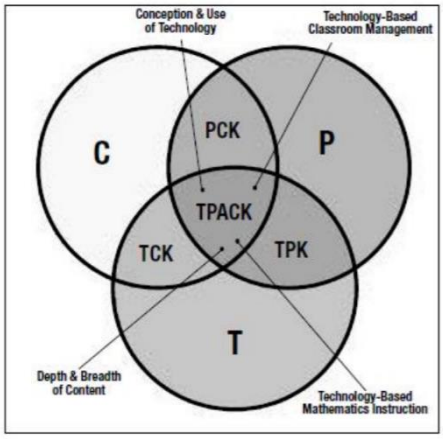

Figure 2.2 Four Central Components of Mathematics-Related TPACK and their Derivation from Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK) (Guerrero, 2010, p. 134)

The ***conception and use of the technology*** component associates the use of technology with PCK, taking cognisance of how technology could be used so that the Mathematical content is easily understood by learners. This takes into account teachers' beliefs about Mathematics as a discipline as well as how Mathematical concepts could best be taught by integrating technology. How teachers perceive the use of technology to teach Mathematics will aid in teachers' choices whether or not to incorporate technology. When teachers make the choice to use the available technology, they have to initially investigate which is the most suitable to achieve the outcomes, and how the selected technology could be optimally used to ensure that the Mathematical concepts are comprehensible to learners. "*Most important, this component includes the knowledge of how to use technology in pedagogically appropriate ways that support instruction authentically rather than as a side-show tool*" (Guerrero, 2010, p. 135). Since the use of technology is dependent upon the knowledge and abilities of learners, the

classroom environment as well as a teacher's pedagogical and technological knowledge, it is incumbent upon the teacher to employ the most suitable pedagogy when integrating technology due to the diverse learners in each class. "*However, most researchers agree that, in general, pedagogically appropriate use implies a seamless integration of technology that promotes inquiry, reasoning, contextualized learning, and sense-making*" (Guerrero, 2005 in Guerrero, 2010, p. 135). In addition, teachers need to be knowledgeable of the various technologies available to teach Mathematics. Due to the dynamic nature of technology, this knowledge will assist them in selecting the most appropriate technology to teach a particular Mathematical concept.

According to Guerrero (2010), the "… *technology-based Mathematics instruction*" component pays particular attention to teachers' pedagogical knowledge and skills to enhance the learning of Mathematical concepts with the use of technology. She added that although various teaching tools are available, the use of technology should be considered. In addition, Guerrero (2010, p. 135) pointed out that technology "… *does not replace the teacher or any type of instruction, but should be included as part of a teacher's instructional repertoire*". With the advent of paperless classrooms in Gauteng, the emphasis was on the sole use of technology in a paperless context. This was in contrast to Guerrero's (2010) understanding of the use of technology as a teaching and learning tool for Mathematics. Guerrero is a professor of Mathematics Education at the Northern Arizona University. She was responsible for both undergraduate and postgraduate courses in Secondary Mathematics Methods, Mathematics for Elementary Teachers as well as Mathematics Educational Technology, so what she articulated was significant and valuable for Mathematics teachers. It is necessary to take cognisance of her sound advice that technology is merely one of the tools that may be used for teaching and learning and when integrating technology in teaching and learning, teachers should question whether the use of technology is the most appropriate teaching tool to achieve the learning objectives of a specific topic. Thereafter, they need to decide which of the various available technologies is most suitable to accomplish the objectives of the lesson. Guerrero (2010) added that the teacher should set limits regarding the extent to which learners should investigate a particular topic. Not all learners are partial to the use of technology in teaching and learning. Therefore, teachers should take cognisance of this as well as other factors, such as the diverse technological and Mathematical abilities of learners, which could inhibit their progress if their needs are not considered.

A teacher's ability to manage the classroom is an additional facet to this component as the use of technology creates diverse challenges as well as possibilities.This is the third component of TPACK, namely ***technology-based classroom management*** (Guerrero, 2010). Learners' attitudes and behaviour alters when technology is introduced in teaching and learning, therefore, teachers need to be aware of classroom management strategies to address behavioural problems. Several studies cite the inappropriate use of technology in the classroom, which demands additional attention from the teacher. The teacher has to contend with the management of learners' disruptive behaviour to ensure that teaching and learning takes place. Although teachers believed the use of technology improved the teaching process, they firmly believed that because learners used technology inappropriately, the quality of learning declined or worsened (Matwadia, 2018). However, Guerrero (2010) pointed out that the use of technology may have a positive effect on learners' behaviour if they are gainfully engaged in classroom activities. This component of TPACK also includes teachers' knowledge of how to function in the classroom environment, such as controlling the physical space, which includes the amount of light or glare in the room. Also, teachers must have the requisite knowledge to troubleshoot technological problems to ensure the successful completion of the lesson.

The ***depth and breadth of content*** refers to the extensive knowledge of the Mathematical content that teachers need to possess when incorporating technology in teaching and learning. This knowledge will give them the confidence to provide solutions to learners' queries. When teachers have an in-depth understanding and knowledge of the subject content (Mathematics), they would be able to clarify Mathematical misconceptions. Despite having a sound knowledge base of the subject content, it is important for teachers to acknowledge their shortcomings in this respect. One of the benefits of technology is that learners can access unlimited content on a specific topic to which they may require answers or guidance when teachers are not suitably equipped to respond. Consequently, it is imperative that teachers should not shy away from such experiences but be prepared to devote time and energy to explore these topics. Table 2.2 below provides questions that Mathematics teachers could use to guide their choices when integrating technology in teaching and learning.

Table 2.2 Questions to Guide the Development and Use of Technology by Analysing Each Component of TPACK (Adapted from Guerrero, 2010, p. 138)

Components of TPACK	Questions teachers should ask themselves
Technology-based Mathematics instruction	• Is technology the most appropriate tool to teach and learn this concept? • What would the effect of technology-use have on learner collaboration? • Will I be able to adjust my teaching from learners' feedback and progress? • How will I adapt my teaching style to suit the diverse needs of learners?
Technology-based classroom management	• How will I manage learners' access to technological devices? • Do I have the expertise to troubleshoot when technology or Mathematical software is problematic? • How do I manage learners' behaviour and progress? • How do I promote and maintain learners' interest in lessons using technology?
Depth and breadth of Mathematics content	• Do I have sound Mathematical knowledge to respond to learners' queries over and above the scope of the lesson? • Am I prepared to admit my deficiencies regarding the Mathematical content and to devote time to investigate and address learners' content queries?
Conception and use of technology	• Is the use of technology the best teaching tool for this topic? • Can the use of technology enhance the teaching and learning of the specific topic? • What should learners learn about this topic through the use of technology? • How pedagogically appropriate is the use of technology for this lesson? • Do I have the technological expertise to use the various features of the available Mathematical tools? • Will technology be completely incorporated to teach the topic, or will technology be used to supplement the content? • Which technology can I use to best teach a specific topic?

Schmidt, Baran, Thompson, Mishra, Koehler and Shin (2009) stated that teachers who have TPACK, understand the relationship between CK, PK and TK, and how this interpretation allows them to teach by using appropriate pedagogical and technological strategies. For instance, if teachers use any type of Dynamic Geometry Software (DGS) to teach a geometrical concept, they should understand how to use the representations of the concept. In addition, they should understand the related pedagogical techniques required to best illustrate the concept in DGS, along with understanding any challenges or benefits of using it. They should also comprehend how DGS could be helpful for learners to investigate and learn the Mathematical concept.

As TPACK necessitates confidence to efficaciously merge the various knowledge domains, it is therefore, associated with teachers' self-efficacy beliefs, which inadvertently influences learners' achievement (Sahin, Akturk & Schmidt, 2009). Consequently, a thorough

understanding of TPACK is necessary for teachers to integrate technology effectively in the classroom. However, "… *because of many inefficient teacher training programs, teachers have difficulties in relating technology, pedagogy and content knowledge [to] each other*" (Erdogan & Sahin, 2010, p. 2707). For that reason, it is imperative that both preservice and in-service teachers obtain a thorough understanding of the three main components of knowledge (technology, pedagogy and content) while attending training on how to integrate technology in teaching and learning (Erdogan & Sahin, 2010). The development of teachers' TPACK, therefore, is dependent upon "… *the effective use of technology in order to increase the quality and effectiveness of education during the process of teaching a particular content from planning to evaluation in an efficient manner*" (Efilti & Çoklar, 2013, p. 349). Meyer and Gent (2016, p. 36) added that the TPACK framework "… *reinforces the view that a number of issues need to be considered when introducing technology into teaching and learning, and that these issues relate to the integration with pedagogy, rather than to a focus on technology*".

Niess (2006, p. 197) added that more intensive research should be conducted on how to develop the TPACK of preservice teachers through "… *content courses, methods courses, assessment courses, and pedagogy courses as well as in student teaching*". The Association of Mathematics Teacher Educators (AMTE), is an organisation established in the USA that is responsible for the development of standards regarding the improvement of Mathematics teacher education. AMTE believes that learners would benefit considerably from technology-enriched teaching and learning environments. As a consequence, they developed a framework based on the work of Mishra and Koehler (2006) to serve as a guide for both Mathematics teachers and researchers, who are involved in the planning, examination, improvement and evaluation of Mathematics teaching (AMTE, 2008). The framework focused on enhancing learning Mathematics through the use of technology. It was therefore, organised around the following four key areas: planning and developing technology-enhanced learning experiences, the assessment and evaluation of Mathematics teaching and learning augmented with technology-use, the facilitation of technology-integrated teaching, and lastly, the on-going development of teachers' TPACK. The AMTE were concerned with teachers receiving the correct and requisite training to teach Mathematics during their preservice years, focusing on technology for the enrichment, enhancement, and the reinforcement of the use of technology in the teaching and learning of Mathematics. At no point does the AMTE mention that the use of technology should replace the traditional method of pen and paper in teaching and learning.

Similarly, the South African White Paper on e-Education (Department of Education, 2004) specified that technology should enhance teaching and learning, however, nowhere does the White Paper emphasise the context of a paperless environment. For teaching and learning in a paperless context, it would require teachers to have impeccable technology skills. However, as presented in the literature in Chapter Three, there are various obstacles that continue to inhibit the successful integration of ICTs in teaching and learning. These obstacles may be traced back for more than a decade and continue to persist. As these obstacles are experienced globally, the expectation to teach and learn Mathematics in a paperless context becomes unrealistic and therefore, not viable.

A study conducted by So and Kim (2009, p. 108) that focused on examining preservice teachers' perceptions of TPACK as well as their ability to apply TPACK in designing lessons, revealed that preservice teachers "… *tended to use technology as a mere delivery medium rather than an instructional tool supporting cognitive activities"*. The lessons designed by the participants in So and Kim's (2009) study required low order thinking skills instead of high order skills on the part of the learners. Therefore, the intricacy of designing lessons that would involve the use of technology to support cognitive activities is dependent upon teachers having a thorough understanding of the subject content, a knowledge of learners' diverse learning abilities as well as the most appropriate method that could be used to convey the subject matter for learners to grasp the concepts. What is evident from So and Kim's (2009) study was that teacher training institutions are not adequately preparing teachers to effectively integrate technology in teaching and learning. Perhaps this may be the reason why technology is used superficially; to merely deliver the content instead of focusing on the enhancement of learners' cognitive abilities. As a result, "… *efforts in identifying and describing the knowledge that teachers must rely on for teaching with current and emerging technologies such as TPACK has energized the teacher education community in reconsidering how the teacher preparation programs needed to be redesigned"* (Niess, 2011, p. 314). In addition, Niess (2011) pointed out that teacher educators are revising and redesigning their educational programmes aimed at developing this specialised knowledge that is required when integrating technology in teaching and learning.

For in-service teachers, Niess (2006, p. 198) advocated that professional development programmes be implemented. These programmes should focus on assisting teachers to acquire

the technological knowledge to teach the subject content and *"... these programs need to recognize and emanate from the teachers' experiences and provide them with extended experiences in teaching Mathematics with technology*". She added that it was important that these professional development programmes provide in-service teachers opportunities to work together regarding the preparation of Mathematics lessons, to illustrate and share new or different teaching methods as well as to use their peers to practice solving problems.

Summary

Considering the ubiquitous nature of technology, educational departments globally are insisting upon the use of technology for teaching and learning; more so in paperless schools in Gauteng, South Africa, where only technology is supposed to be used in the classroom. However, the successful implementation of technology in the classroom is largely dependent upon teachers' TPACK. This enables teachers to take advantage of technology as a powerful tool, otherwise, they will merely use it to replicate the traditional method of teaching and learning. Teachers need to understand the dynamic nature of technology and have the requisite knowledge and skills to use these optimally. Due to the pervasive nature of the internet and social media, it becomes important for teachers to take advantage of such opportunities to enhance the teaching and learning process. However, to reiterate, the integration of technology in the classroom must be supported by pedagogy. Additionally, "… *individual teachers, grade-level, school-specific factors, demographics, culture, and other factors ensure that every situation is unique, and no single combination of content, technology, and pedagogy will apply for every teacher, every course, or every view of teaching"* (Koehler, 2012). Guerrero (2010, p. 135-136) agreed:

> *... technology use depends on the specific needs and nuances of each student, class, and teacher, pedagogically appropriate use of technology may vary from classroom to classroom… Using technology with every activity and for every instructional purpose is just as futile as using direct instruction for every topic and lesson.*

The next chapter provides a review of the pertinent literature regarding the use of ICTs in teaching and learning.

CHAPTER THREE

LITERATURE REVIEW

Introduction

A literature review aims to provide an overview of previous studies, existing research and debates that are relevant to the current study. This chapter, therefore, examines literature that is pertinent to this study, which investigated the viability of teaching and learning Mathematics using ICTs in a paperless classroom. A literature review may be used as a benchmark to draw comparisons between current literature and previous studies (Creswell, 2002). Since Paperless classrooms are a new phenomenon resulting in a paucity of literature on classrooms that function in a "truly" paperless context, benchmarking becomes difficult.

There appears to be an abundance of anecdotal evidence on paperless classrooms, both globally and locally, however, none of the sources found depicted a "truly" paperless context. This is evident in a school in Cleveland, USA, which claimed to be paperless. However, they still use hardcopy textbooks and set technology aside for use when required (D'Avolio, 2016; Rutson-Griffiths, 2014). To reiterate and as established in Chapter One, the concept paperless classrooms may be interpreted as the absence of pen and paper in teaching and learning and only digital technology would be used in the classroom. Although a lack of literature pertaining to "truly" paperless contexts exists, there is, however, a plethora of literature pertaining to the use of ICTs in teaching and learning. The discussion that ensues focuses specifically on the integration of ICTs in education.

Today's learners have changed due to them being born in an era where technology is ubiquitous. Such learners are immersed in the use of technology and spend numerous hours occupied with their technological devices such as smartphones, playing games, interacting on social media or browsing the internet (Prensky, 2001). These learners are referred to as "*digital natives*" because they were born in the digital age, are comfortable with the use of technology and believe technology to be important, essential and central to their lives (Halton, 2019). Those not born in the digital age are referred to as "*digital immigrants*". Brown and Czerniewicz (2010) claim that assigning such labels to individuals implies that if a person

belongs to one category then he/she cannot belong to the other. They allude that "… *age is not a determining factor in students' digital lives; rather, their familiarity and experience using ICTs is more relevant … that the notion of a generation of 'digital natives' is inaccurate: those with such attributes are effectively a digital elite"* (Brown & Czerniewicz, 2010, p. 357). The same can be said about teachers. Although many young teachers today fall into the category of "digital natives" or more precisely "born in the digital era" it would be presumptuous to assume that they would be technologically competent and more inclined to employ the use of technology in their teaching. More often than not teachers whether labelled as "natives" or "immigrants" may teach the way they were taught. For this practice to change, proper mentoring, coaching and training is integral to increase the use of ICTs in teaching and learning.

Although learners may be skilled in technology-use, they still depend largely on the teacher for knowledge dispersion through digital mediums. However, teachers need to be aware that not all learners born in the digital era may be proficient at using technology. Brown and Czerniewicz's (2010, p. 360) study revealed that *"... students born into the millennial generation cannot be assumed to have grown up digital, nor can homogeneity be assumed in terms of computer experience. Rather, it is evident that the range of skills and experience of the students within 'the millennial generation' is diverse*". In addition, the socio-economic status of many learners denies them access to technologies, such as smartphones, tablets or computers. Therefore, the assumption that all learners have the necessary technological skills because they are born in the digital age, could be detrimental to teaching and learning.

To use ICTs effectively in the classroom, teachers need to deliver the subject matter in an interesting and creative way, thus making learning quick and easy (Kler, 2014). Learners benefit considerably with the use of ICTs when they search on the internet for information relating to learning activities on specific subject content. In addition, they use technology to access social media to communicate with peers and other learners. Fu (2013) concurred that ICTs assist with the attainment of knowledge as well as promoting learners' comprehension of subject content. The aim of integrating technology should be for the sole purpose of enhancing the teaching and learning process, and not to replace the teacher nor replicate the traditional-based face-to-face method of teaching and learning.

Prior to the integration of technology, pedagogy and subject content knowledge was key. However, when technology is integrated into teaching and learning, technology knowledge and skills become a prerequisite. Various factors need to be considered before teachers choose to integrate technology in their lessons because these factors will contribute to the success or failure of technology integration. Meyer and Gent (2016, p. 1), who compiled a report entitled "*The Status of ICT in Education in South Africa and the way Forward*" on behalf of the National Education Collaboration Trust cautioned:

> *Critical success factors include that solutions must be tailored to the readiness of schools to adopt technology (there is no 'one-size-fits-all'), and must be designed with cognisance of resource constraints, and requirements for successful handover. A holistic view is essential, and must incorporate multiple dimensions in creating solutions, include multiple role players, and cater to multiple levels within the education system. Merely providing computer hardware and software is guaranteed to fail.*

Cognisance should be taken of the above warning especially as large amounts of money would have to be initially spent on the purchase of technology, which often bears additional costs regarding maintenance afterwards. Research needs to be conducted to ensure schools, teachers, learners and parents are adequately prepared to accept, protect and use the provided technology, otherwise the purchase and implementation of technology in schools would result in a waste of Government resources and taxpayers' money. Research indicates that in many cases technology is not being used in the classroom because of various factors. However, most important of all, is that teachers lack the necessary technological skills to use the provided technology (Minty & Pather, 2014; Funkhouser & Mouza, 2013). Monyooe (2015, p. 1) added:

> *South Africa still grapples with deeper systemic challenges that include (not limited to): unequal infrastructure, differentiated teacher qualifications and profiles, lapses in school leadership, lack of regional support capacity and lack of shared stakeholder commitment to successfully implement policy directives… Eskom's strained power grit[d], rampant poverty and crime add to a toxic mix.*

Despite being aware of these challenges that continue to plague South African schools, the Government continues to spend large sums of money on the acquisition of digital technologies to be used in the classroom; the paperless initiative at Gauteng schools being the latest. In addition, before deciding to implement technology in teaching and learning, teachers must ascertain whether the use of the selected technology would enhance the teaching of the specific subject content (in this study, Mathematics). According to Niess, Lee and Kajder (2008) as cited in Niess (2006), before employing technology, teachers should ask themselves the following pertinent questions: *Will the use of technology provide a more effective method to understand the content and cater to the diverse needs of learners in the classroom; can*

learners' cognitive skills be developed through the use of technology; what knowledge and skills must both the teacher and the learner possess prior to implementing this tool; and finally, when the content is assessed, will this assessment be conducted using the same tool? The answers to these questions should enable teachers to make the appropriate choices regarding technology integration. Numerous studies, as discussed in the next section, have been conducted, both globally and locally, concerning the integration of ICTs in teaching and learning. These studies have highlighted several factors that contribute positively towards the integration of ICTs in teaching and learning.

ICTs in Teaching and Learning

To develop the motivation to use ICTs, it is essential that teachers find the relevance for their integration, as teachers who are not ready nor confident in using technology are unlikely to integrate technology into their pedagogy (Minty & Pather, 2014; Ainley et al., 2010; Chigona & Chigona, 2010; Lau & Sim, 2008). Ainley et al. (2010) pointed out that if there is a supportive environment, this may contribute to teachers' confidence to integrate ICTs in their classrooms. By equipping teachers with the requisite knowledge and skills, they should be confident and ready to explore the various techniques that may be used to incorporate technology in their teaching to enhance the learning process. Consequently, it may be assumed that the successful integration and the use of technology in teaching and learning is dependent upon the support that should be provided by the school as well as the opportunities for teachers and learners to improve their ICT skills. Koehler and Mishra (2009) claimed that when teachers integrate technological, pedagogical and subject content knowledge, they spontaneously implement TPACK during teaching and learning. Therefore, for teachers to have the confidence to integrate ICTs in their classrooms, it would be necessary for them to have sound technological, pedagogical and subject content knowledge and skills.

A recent study conducted in a secondary school in Malaysia revealed that despite the school being adequately equipped with ICT facilities, other factors, such as the lack of time, teacher workload, lack of ICT skills and teachers' negative attitudes towards the use of these, impeded the incorporation of ICTs in teaching and learning (Aziz & Shah, 2015). Another study conducted at selected secondary schools in Malaysia, revealed that self-perception and attitudes of Mathematics teachers prevented them from integrating ICTs in their pedagogic practices

(Abdullah, Mokhtar, Kiong, Surif, Ali & Ibrahim, 2016). These findings are supported by Mahdum, Hadriana and Safriyanti (2019) and a study conducted by Mukhari (2016). The provisioning of ICTs and ICT facilities should not be a problem at Gauteng paperless schools as these schools have been equipped with smartboards, Wi-Fi access, and all learners have been provided with tablets by the GDE. However, what needed to be investigated was whether teachers had the requisite support as well as the technological and pedagogical knowledge and skills to integrate technology in the Mathematics classroom.

Ndlovu and Lawrence (2012) added that the ICTs that were selected by teachers to use in their lessons was largely dependent upon the teacher's ability to incorporate that tool in the subject that was being taught. The GDE however, did not offer teachers nor the school any choice regarding the selection of ICTs but rather supplied all paperless schools with smartboards and learners with tablets. Not everyone is comfortable with using a tablet and may prefer to use a laptop instead. A study conducted by Korkmaz and Cakil (2013) that investigated "*Teachers' difficulties about using smart boards*" revealed that despite teachers acknowledging the various advantages of using the smartboard such as it saves time because work can be saved, edited and reused as well as it makes topics easier to understand, more enjoyable and interesting to learners, teachers admitted that they lacked the technical expertise to use the smartboard. The participants in Korkmaz and Cakil's (2013) study indicated that the technical difficulties that they experienced, disrupted the smooth flow of the lesson, which directly influenced how often they used the smartboard in their lessons. They indicated that they used the smartboard mostly when

> *… they want to share visuals with the students and when it is necessary to make drawings. In addition, teachers also need these technologies in solving questions or giving examples in order to emphasizing [emphasise] on the topics". A "lack of suitable presentations and instructional materials, teachers' inability to fix technical problems by themselves, and not making adequate preparation before the classes are the other barriers hindering the use of these technologies [smartboards]* (Korkmaz & Cakil, 2013, p. 598).

There are several pedagogical strategies that teachers may choose to incorporate the various ICTs in teaching and learning such as the use of multimedia, social media, games and technology as a tool for empowerment. This is where the pedagogical knowledge of the teacher is important; the teacher must choose the most appropriate strategy to teach the subject content. For the use of technology to be effective, teachers must be willing and enthusiastic to incorporate technology in their teaching and learning (Kler, 2014). Hubber, Outhwaite,

Chigeda, McGrath, Hodgen, and Pitchford (2016) added that the "*one laptop per child (OLPC)*" project, despite being the most well-known strategy to implement digital education technologies in the classroom, had partial success due to inadequate implementation and insufficient teacher training. If teachers are provided with the appropriate training regarding ICT integration and how to use the necessary software to teach the subject content, it will be valuable and may influence teachers' willingness to incorporate ICTs in their classrooms (Umugiraneza, Bansilal & North, 2018; Lawless & Pellegrino, 2007 in Kler, 2014). This view regarding training and specifically related to the teaching and learning of Mathematics, is supported by Obara, Nie and Simmons (2018, p. 1347) who advocated that:

> *... for the benefit of new technological innovation to be realized, Mathematics teachers need continuous and relevant training and support. As technology rapidly advances, this need will most likely continue. If teachers perceive that there is enough time for training or that the availability of technological resources is appropriate, they will make an effort to obtain the technology training they need and desire. Furthermore, there must be an obligation to plan and coordinate staff development in ways that will promote change in teacher practice.*

Stols, Ferreira, Pelsar, Olivier, Van der Merwe, De Villiers and Venter (2015) reported that Mathematics teachers were reluctant to employ technology in their classrooms because they found its integration to be overwhelming. In addition, their perceptions regarding their lack of technological skills indicated a necessity for additional training. Meyer and Gent (2016, p. 1) reported that although the ICT strategy and policy documents exist at South African schools, "… *implementation is slow and capacity is limited*". They cited unequal opportunities and limited technology as reasons for the slow implementation of technology and that solutions implemented are oblivious to resource constraints experienced at schools. They, therefore, recommended that the focus of ICT implementation should be on developing the capacity at schools:

> *A phased approach, with appropriate interim targets, needs to be taken. Progress should be measured against multiple criteria, and the focus should be on measuring the capacity of the system to integrate technology, and the capacity of teachers to incorporate technology into the process of teaching and learning* (Meyer & Gent, 2016, p. 1).

Drawing on Meyer and Gent's (2016) recommendation, it is apparent that teachers' capacity to integrate ICTs has not been developed sufficiently. Therefore, for the Gauteng MEC to firmly believe that the use of ICTs in teaching and learning would automatically lead to an improvement in learners' academic performance, is far-fetched and unrealistic. Evidence of the under-development of the capacity of schools and teachers included in this study may be found in Chapter Six, where the results pertaining to school capacity is presented. A discussion

follows of the various factors contributing to the successful integration of technology in the curriculum.

Factors that Contribute Towards the Successful Integration of ICTs

Newhouse (2002, p. 12) claimed that "… *historically, technology has been developed to solve problems, improve living standards and to increase productivity*" and therefore, the development of educational technology should serve a similar purpose which is to "… *increase productivity*", "… *solve problems in teaching/learning programmes*" and that "… *educational technology should influence educational outcomes and costs".* The procurement of technology (hardware and software) for schools, the training required to skill teachers to use the technology effectively, as well as the maintenance of such technology is costly and need to be weighed against the anticipated outcomes (Newhouse, 2002). He firmly believed that the selected ICT for the classroom should be the best method to achieve the outcomes of the curriculum. If that technology is not going to be used effectively by teachers, then it must not be used at all. In addition to the list of questions that Korkmaz and Cakil (2013) proposed that teachers ask themselves before employing technology, Newhouse (2002, p. 13) proposed that teachers further consider the following two pertinent questions; "*Where are the problems to be solved and tasks to be completed?*" and "*Is a computer solution the most effective approach?*" Being in the 4th Industrial Revolution where "artificial intelligence" and "robotics" are the new buzz words, Governments both globally and locally are insisting upon the use of technology in teaching and learning. However, Newhouse (2002) pointed out that it is imperative to investigate whether in reality and practice the use of ICTs has a positive influence on learning, teachers and learners.

Research supports the above claims that the use of ICTs in teaching and learning is influenced by the following: availability and accessibility of the relevant technology at schools, teachers' beliefs, teachers' and learners' attitudes and skills, time to design lesson plans to integrate technology to teach the subject content, support and leadership that is offered by the school, teaching workloads, as well as the pressure to prepare learners to write examinations that follow the traditional method of paper-based assessments (Hyndman, 2018; Aziz & Shah, 2015; Chan, 2015; Howard et al., 2015; European Schoolnet, 2013; Minty, 2011). In addition, a study conducted in Tehran (Iran) that investigated both novice (less than two years of teaching

experience) and experienced English First Language teachers' perceived TPACK and how it influenced their professional development, revealed that although teachers believed that technology integration in their lessons was important, a participant articulated that the "… *lack of organizational facilities, lack of administrative support, and insufficient teachers' digital literacy could be regarded as barriers for technology integration in classrooms"* (Nazari, Nafissi, Estaji & Marandi, 2019, p. 16).

Another study, conducted in Pakistan, which aimed at determining the attitude of Science teachers towards the pedagogic integration of ICTs, found that teachers were enthusiastic about the use of ICTs in their teaching even though they viewed ICTs as only using the computer and the data projector (Khurshid & Mashhadi, 2014). It may be inferred from the above that teachers are comfortable and confident to use the computer and the data projector and therefore, limit the use of ICTs only to these two technologies. It is, therefore, important to note that for teachers and learners to be comfortable using technology, irrespective of the context (paperless or not), training is crucial. In addition, Porter, Barbagallo, Peck, Allen, Tanti and Churchill (2020, p. 14) stated "… *students had to be orientated in the process of learning in an online and blended learning [BOLD] environment, and that the content had to be delivered in such a way as to genuinely engage the students in the learning journey"*. If students/learners are not engaged with the material or they lack ICT skills, this would impede the successful integration of ICTs in teaching and learning (Abdullah et al., 2016; Mukhari, 2016; Albugami & Ahmed, 2015).

To add to the above-mentioned factors that influence ICT use by teachers, it is important for the entire school to "buy into" the idea of ICT implementation because it was found that individual teachers experienced difficulty to effect the necessary changes (Voogt, 2012). If teachers can see the connection between the pedagogical aims and how ICTs can be used to achieve these aims, they will realise the value of using ICTs in the classroom. Collaboration with other schools as well as the business world, is also mentioned as important elements that contribute towards the sharing of ideas and approaches, as well as keeping abreast of current developments regarding the use of technology (Voogt, 2012). Since teaching and learning in a paperless context is a new phenomenon, the sharing of ideas, approaches and experiences would provide the necessary support and knowledge to teachers in such an environment. This subsequently may contribute to the viability of teaching and learning in a paperless context.

Keser, Yılmaz and Yılmaz (2015) investigated preservice teachers' competencies regarding TPACK and their self-efficacy perceptions towards technology integration and found that these were a significant predictor of their TPACK. In Mahdum et al.'s (2019) study that explored what motivated Indonesian teachers to use ICTs in learning activities revealed that teachers' self-efficacy perceptions, the values that teachers uphold regarding education, the impact of ICTs on teaching and learning as well as the training they had attended, greatly influenced their use of ICTs in the classroom. Another study, conducted by Taha (2014), revealed that student and teacher characteristics, the technology used, the design of the course and the quality of the content, had a significant influence on the success of e-learning strategies. Student characteristics, such as their computer literacy skills, their motivation and their attitudes, coupled with teachers' attitudes, the choice of which technology to use, their pedagogy and teaching styles, contributed to the success of e-learning.

ICTs tools are believed to assist learners to increase their digital information competently and successfully to solve problems. Another aspect that benefits the use of ICTs in teaching and learning is that learners are often focused and involved in the precise reason for the use of computers. Learners construct new knowledge using a computer to access, select, organise, and interpret information and data. Therefore, by integrating ICTs in learning, students become skilled at selecting and using data retrieved from a variety of sources that they have critically evaluated (Fu, 2013). A creative learning environment is produced with the use of ICTs because they provide innovative ways to the various categories of learning.

Furthermore, collaborative learning is enabled using ICTs because learners can work together, communicate and share whatever knowledge they have accessed. The integration of ICTs in teaching and learning will contribute to learners' application of technology, their achievement of higher cognition levels, improve the quality of teaching and learning as well as play a supportive role in facilitating access to subject content (Fu, 2013). It was found that academic achievement is enhanced with the use of ICTs in teaching and learning. However, House (2010 in Cheema & Zhang, 2013) pointed out that not all activities using a computer improve academic achievement. Recent research has suggested that there are positive results from the use of educational technology but these results are minimal when compared with results obtained using traditional methods (Cheung & Slavin, 2013). GeoGebra software that is currently used by some Mathematics teachers, provides important teaching and learning

possibilities for both teachers and learners in the Mathematics classroom. This software can be downloaded from the website[5], for free. Although the integration of technology in the classroom is beneficial to learners, it is important not to lose sight that several factors exist that inhibit the successful use of technology in teaching and learning; these are discussed below.

Factors that Inhibit the Incorporation of ICTs in Teaching and Learning

Research indicates that the effective integration of ICTs in the classroom is largely dependent upon the availability of the school's ICT infrastructure, the technical and managerial support, and the teachers' acceptance of ICTs in education (Mukhari, 2016; Minty & Pather, 2014; Tedla, 2012). Teachers from Abdullah et al.'s (2016) study indicated that they were reluctant to incorporate ICTs in their classrooms because they lacked the technical expertise to deal with problems that might arise when using technology and they perceived the use of technology to be complicated. Mirzajani, Mahmud, Ayub and Luan (2015) and Mukhari (2016) added that teachers were unable to integrate technology into their lessons because of inadequate training, lack of knowledge and skills on how to use the technology, and a lack of time. A detailed discussion of the factors inhibiting the integration of technology in classrooms, is provided in Chapters Six and Seven.

A framework developed by Newhouse (2002) depicts the interconnections between the diverse entities; such as the curriculum, teachers, students/learners, the community, the educational system, the school system and ICT resources that influence the use of ICTs in teaching and learning. This concept map (Figure 3.1) indicates the relationships between the entities of both the learning and external environment when using technology in the classroom.

[5] www.geogebra.org

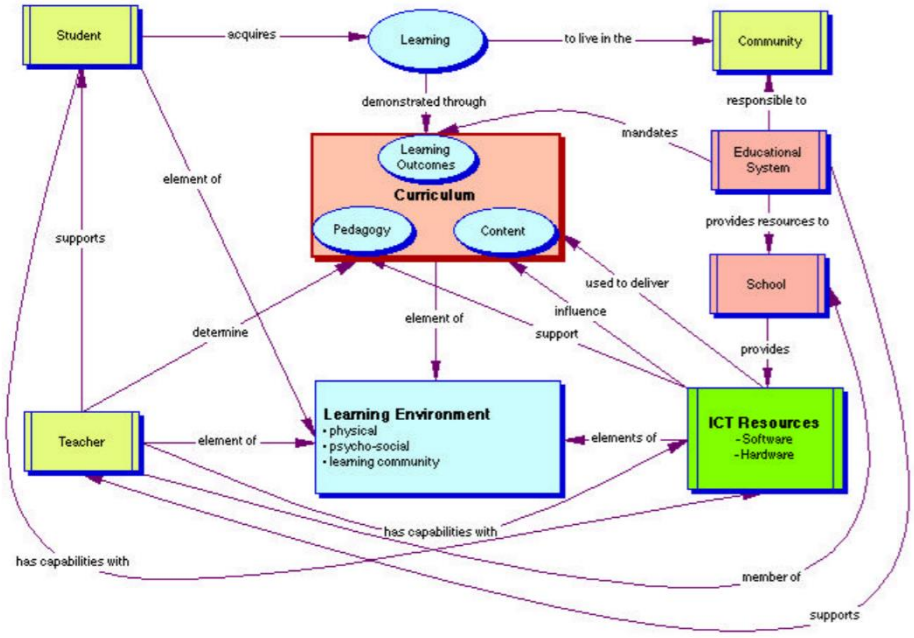

Figure 3.1 Concept map indicating relationships between learning environment entities and external entities (Newhouse, 2002, p. 15)

Although various factors may inhibit the successful integration of ICTs in teaching and learning, Newhouse (2002) and Abdullah et al. (2016) claimed that the most critical obstacle was the unavailability of appropriate ICT resources. These have a direct influence on the pedagogy used by the teacher to achieve the learning outcomes of the subject. Therefore, the selection and provision of appropriate hardware and software are imperative for the successful integration of ICTs in teaching and learning. Besides suitable resources, technical support is crucial. If teachers and learners lack the necessary skills to use the educational technology, this would impede teaching and learning, resulting in the learning outcomes possibly not being achieved (Kganyago, 2018; Mukhari, 2016) as found in studies conducted at South African schools. Some of the challenges as expressed by the participants in Kganyago's (2018, p. iii) study were "… *insufficient training and technical support, anti-social behaviour by learners and technophobia by older teachers*". Mashile's (2017) study at South African schools coincides with Mukhari's (2016) and Kganyago's (2018) research, which revealed that the training and the professional development of teachers was lacking. The majority of teachers had basic ICT skills, which they taught themselves. For ICT to be integrated effectively into the curriculum to positively influence learners' academic performance, teachers must have advanced ICT skills. However, since the majority of the teachers in South Africa lack these (Minty & Pather, 2014; Funkhouser & Mouza, 2013; Minty, 2011), the continual investment

in providing technology to schools would merely be used to replicate face-to-face teaching rather than enhancing teaching and learning. Moreover, the paperless context appears to be an impossibility considering the ICT skill levels of the majority of the South African teachers.

The importance of Newhouse's (2002) framework is that all entities play a fundamental role in influencing whether ICT integration in education will be successful or not. Ryan and Bagley (2015) claimed that the integration of technology in teaching and learning can be distinguished and comprehended as an effort to conquer both external and internal barriers. The external barriers refer to; the changing nature of technology, the lack of appropriate hardware and software for teaching purposes, the ineffective professional development of teachers (both in-service and preservice) and continuing technological support. The internal barriers include; teachers' beliefs, theirs views and understanding of how to use technology, which may cause distress, anxiety and a lack of confidence relating to technology integration. Albugami and Ahmed (2015, p. 42) expanded on these internal and external barriers providing additional factors that influence ICT-use by teachers as shown in Figure 3.2 below.

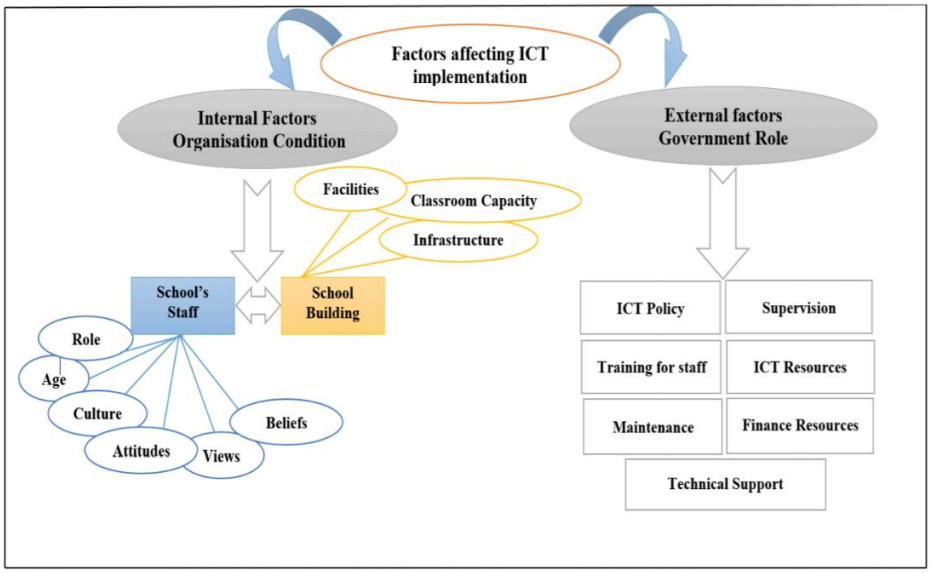

Figure 3.2 Internal and External Factors Affecting ICT Integration in Education (Albugami & Ahmed, 2015, p. 42)

The internal factors include; the school's infrastructure, the role, age, culture, attitudes, views and beliefs of all school staff members. The external factors focus on; the Government's role for the provision of an ICT policy, ICT resources to schools, appropriate training for all staff members, financial and technical support, and the maintenance and upkeep of the ICT

resources. All these factors are critical for the successful implementation of ICTs and more so for teaching and learning to be conducted in a paperless context. To reiterate, this study elicited the very same findings that concur with Albugami and Ahmed (2015), a detailed discussion of these factors may be found in Chapters Five, Six and Seven.

The South African White Paper on e-Education (Department of Education, 2004) stipulated the requirement that teachers integrate ICTs in the classroom to enhance teaching and learning, to prepare learners adequately to function in the 21st century and to bridge the "digital divide". However, a study conducted by Umugiraneza et al. (2018) that included seventy-five KwaZulu-Natal Mathematics teachers, found that the calculator was the only tool that was used most commonly by these teachers to teach Mathematics and the majority of the participants indicated that they rarely used computers to teach. The study also revealed that only, approximately 25% of the teachers had access to ICTs for the teaching and learning of Mathematics, providing evidence that the digital divide is still prevalent in the poorer communities in South Africa, despite the dictum by the Government in 2004 that teachers integrate technology in their teaching and learning. From the literature there are many other obstacles concerning ICT integration, which continue to persist in 2020 in South African schools.

Mathipa and Mukhari (2014) investigated the factors that influenced teachers' use of ICTs at selected urban schools in Gauteng. The study revealed that an "… *insufficient number of computers and lack of application programs, teacher generation gap, inadequate teacher training, lack of ICT skill and lack of confidence, teachers' beliefs, poor school leadership and lack of public support*" were factors that impeded the successful use of ICTs in teaching and learning. Considering that numerous studies conducted at South African schools on ICT integration consistently cite the same obstacles and many more which will be discussed later in this chapter, it is questionable as to how the MEC envisioned the possibility of teaching and learning being constructed in a paperless context. It is reasonable to assume that if teachers lacked the necessary knowledge and skills to integrate technology into their pedagogy, the use of ICTs would be detrimental to teaching and learning, particularly in a paperless context.

These impediments, which have been highlighted by researchers, were not addressed before the DoE had invested large sums of money to procure ICTs. Even if the necessary infrastructure

is available, if teachers lack the knowledge and skills to integrate technology in their pedagogy, the use of ICTs in teaching and learning would be futile. Mathipa and Mukhari (2014) therefore, recommended training teachers to integrate ICTs be prioritised by the DoE. Teachers should collaborate with one another to share their experiences and expertise. Obara et al. (2018, p. 1347) recommended that:

> *… a mentor-supported model could be used for professional development in technology to enable teachers to receive the additional support they need to facilitate change when implementing new strategies…The effective mentor-supported professional development could be successful in increasing the integration of technology in the Mathematics classroom when the training is relevant and encourages the integration of technology into the curriculum.*

It was found that the majority of teachers, who use ICTs in other countries, were Science teachers rather than Mathematics teachers (Jones, 2004 in Ainley et al., 2010; Law, Pelgrum & Plump, 2008; Kozma & McGhee, 2003). Science teachers use ICTs in their classrooms more readily compared to Mathematics teachers as the subject content is taught easily with the use of ICTs and there may be a variety of digital resources available to teach the subject content (Ainley et al., 2010). Research conducted by the European Schoolnet (2013) found that the number of times that teachers used ICT tasks in their classrooms differed, this use was dependent upon the grade and the subject.

Subject Content as an Inhibitor to ICT Integration

Howard et al. (2015) investigated the relationship between the subject area and factors that influenced the integration of technology; such as teacher readiness and their beliefs, and found that Science teachers were the most confident, followed by English teachers, whereas Mathematics teachers were the least confident. Furthermore, the study found that teacher beliefs concerning the use of ICTs were influenced by the subject they taught, as subject areas are not homogenous. Both Science and English teachers showed significant positive beliefs relating to the importance of ICT integration compared to Mathematics teachers. This less positive belief could be attributed to the fact that all subject areas are not the same and have a distinctive course over a period with the integration of technology programmes. Similar results were produced from a study by Howard and Maton (2011, p. 201)

> *… their relatively low use of ICTs in the classroom did not reflect an antipathy towards technology per se; mathematics teachers were generally positive towards using technology in teaching and learning. Rather, it was the value for learning mathematics of the knower-code practices often associated with ICTs that was viewed with scepticism.*

Teachers expounded that mastery of Mathematical concepts required constant practice while students from the same study indicated that technology use was "*not very important*" when learning Mathematics (Howard & Maton, 2011, p. 201). Consequently, the subject content should be considered when technology is to be integrated into teaching and learning. As subject content is not homogenous, it was necessary to investigate how viable the use of tablets was in a paperless classroom and whether these were an adequate tool to teach the Mathematical content.

Many teachers in this study have cited subject content as one of the reasons for not integrating ICTs in their classrooms. The European Schoolnet (2013, p.1) survey that focused on Grade 8 and 11 Mathematics and Science teachers' use of ICTs in teaching and learning revealed that the use of ICTs in Grade 11 Mathematics classes when compared to Science classes, was lower. Although the difference in ICT use was not significantly large, it could be attributed to the fact that "*Mathematics and science teachers and students may have specific characteristics that need to be addressed independently*". A possible reason could be that the teaching of certain content for some subjects requires pen and paper, for example in Mathematics, a certain aspect may be less time-consuming to teach and learn when using the traditional method of the chalkboard/whiteboard and pen and paper compared to using a computer, laptop or tablet.

Other subjects may be taught easily using technology; thus, it may be inferred that the subject content is a significant factor that influences teachers' choice regarding the integration of ICTs in their respective disciplines. What is questionable is whether the entire curriculum can be taught solely using technology in a paperless context. Another aspect that should be considered is the learners' opinions about technology being used to teach the content of every subject in a paperless context as not all learners prefer learning using technology only. Baytak, Tarman and Ayas (2011) explored the experiences of six learners who used technology in education. They found that learners firmly believed that technology could not be integrated into all subject areas. One participant indicated that although he might prefer to use technology to learn Mathematics, he did not prefer to use technology when learning Science or Physical Education. Another learner pointed out that music should not be taught using computers. Taking cognisance of this, one wonders how would teaching and learning be conducted in a paperless context, especially as studies demonstrated that both teachers and learners believed that technology cannot be used to teach and learn the content of every subject. Additionally, teacher workloads will increase

if the subject content does not lend itself readily to the incorporation of technology. Teachers would have to search for strategies to incorporate ICTs in their teaching and learning in a paperless context, which inevitably will take more time and effort to prepare their lessons.

Teacher Workload

Numerous studies have identified teachers' workloads as influencing their choice to use technology in the classroom (Aziz & Shah, 2015; Minty & Pather, 2014; Minty, 2011; Abuhmaih, 2011). Several factors contribute to an increase in workloads such as teachers' acquisition of ICT skills, which must be upgraded continuously because digital technology is constantly changing, sourcing new teaching methods for the integration of ICTs as well as the adaptation of the content to use ICTs. All the above serve as a deterrent to the use of ICTs in the classroom (Samarawickrema & Stacey, 2007 in Kler, 2014). Bennell (2004) added that long working hours, large classes, the number of subjects taught by each teacher, as well as the continuous changing of the curriculum, demotivate teachers from integrating technology in their lessons. South African teachers must contend with overcrowding in classrooms, increased workloads, and inadequate infrastructure. Therefore, if teachers are demotivated to integrate technology due to large class numbers, *what would happen when teachers are "forced" to teach in a paperless context with such large numbers of students?* In addition to teachers' workloads, a lack of ICT knowledge, skills and competence of both the teacher and the learner could prevent a teacher from incorporating ICTs in teaching and learning.

Teachers' and Learners' ICT Knowledge, Skills and Competence

One of the challenges that negatively affected the use of technology in the classroom was a lack of technological skills on the part of the teacher (Mukhari, 2016; Albugami & Ahmed, 2015; Mathipa & Mukhari, 2014; Minty, 2012; Tedla, 2012). Belgheis and Kamalludeen (2018, p. 112) investigated Malayasian teachers' intention to use GeoGebra in the teaching of Mathematics. They found that there was a "… *significant positive relationship between teachers' perceived current competencies and their intention to use GeoGebra… teachers who perceive themselves as skilful in the application will most likely use it in their Mathematics teaching"* and vice versa.

Teacher readiness is a fundamental factor that affects their decision to integrate ICTs. Teachers can effectively improve their readiness and confidence to incorporate technology in their classrooms if they receive the appropriate training on how to use the available hardware and software. The absence of suitable training is one of the major challenges cited by teachers as their main reason for not integrating technology in Mathematics classrooms. Belgheis and Kamalludeen (2018, p. 113) recommend that:

> *... should the teaching of Mathematics require integration of software or other technological tools, teachers should be given enough exposure and training in using the technological tool as well as the pedagogical skills to ensure impactful delivery of classroom lessons. It is also imperative for schools to facilitate technology integration in the classroom by providing appropriate infrastructure, infostructure, and professional development support to ensure teachers' relevance in 21st century classrooms.*

It is important that when training is designed and conducted, it should cater to the individual needs of teachers because:

> *Novice teachers were found more competent in their technological knowledge and its combinations, whereas experienced teachers were more knowledgeable in their pedagogical and content knowledge and its combinations. Hence, it was found that novice and experienced teachers need different professional development courses tailored to their needs* (Nazari et al., 2019, p. 1).

Nazari et al. (2019) attribute this difference to the diverse knowledge domains of TPACK of novice (less than 2 years teaching experience) teachers being digital natives. They were born in the digital era, had significant knowledge about the availability of the diverse technologies and knew how to use them. Consequently, their knowledge of TK, TCK and TPK, the components of TPACK, is excellent. Similarly, they claim that because experienced teachers were digital immigrants, they showed higher levels of competence regarding PK, CK and PCK and a lack of technological knowledge. They, therefore, recommended that it is imperative that this significant finding is taken into consideration when providing professional development to teachers.

Şandıra and Aztekina's (2016) study investigated preservice teachers' opinions on the use of the dynamic geometry software (DGS) namely; Cabri II Plus, The Geometer's Sketchpad and GeoGebra for the teaching of Mathematics. They found that teachers preferred the use of GeoGebra because it was user-friendly. They, therefore, suggest that for teachers and learners to benefit from the use of DGS *"... we [need to] obtain more perfect combinations of technology, pedagogy and Mathematics. Even though the advantage of technology in education*

is widely accepted, the ability to flawlessly incorporate technology is not very easy" (Şandıra & Aztekina, 2016, p. 429).

If learners have the requisite technology skills, then teachers may be more confident to include technology in teaching and learning. Learners' lack of the requisite technology skills will negatively influence the teaching and learning process as teachers will have to spend additional time teaching learners the necessary skills to use the technology to their advantage, instead of focusing on the integration of ICTs to teach the subject content. Teachers experienced that trying to accommodate such learners in the classroom resulted in valuable time being wasted and subsequently disrupted teaching and learning (Chigona et al., 2014). In a paperless context, technological skills are quintessential, consequently, the TPACK conceptual framework, within which this study was located, requires teachers and learners to have the necessary technological knowledge and skills. Another aspect that hinders the use of technology in the classroom is a lack of confidence on the part of teachers and learners, as a result of inadequate technology skills.

Lack of Confidence to Use ICTs in Teaching and Learning

A lack of confidence amongst teachers could inhibit their use of ICTs in teaching and learning (Abdullah et al., 2016). This claim is supported by a study conducted by Abdullah et al. (2016) that investigated the factors that prevented Malaysian Mathematics teachers from using ICTs in their classrooms. The fear of failure was cited as the main cause of teachers' lack of confidence (Beggs, 2000 in Kler, 2014; Minty, 2011). This together with inexperience, fear and anxiety, and a lack of competence concerning the pedagogy that underpins the integration of ICTs (BECTA, 2004 in Kler, 2014) might deter many teachers from using technology in their classrooms (Mukhari, 2016; Minty, 2011). Consequently, these teachers resort to traditional teaching methods (Minty, 2011). All the above-mentioned factors appear to underpin teachers' non-use of technology, which may be interpreted as resistance to change.

Teachers' Resistance to Change

"*It isn't that people resist change as much as they don't know how to cope with it*" (Fullan, 2000, p. xii). Fullan's argument is that teachers do not have the knowledge to manage change. Teachers, whose preservice training focused on the traditional teaching methods, have become

very comfortable with these teaching methods and therefore are resistant to change. Abdullah et al. (2016, p. 5) asserted that Mathematics teachers' lack of:

> *... exposure to use ICT in their degree studies resulted in unfamiliarity with the facilities which in the long run suppressed their intention to use ICT in teaching Mathematics. In other words, if teachers are exposed to ICT at the early stage of their career, they may be interested with its potential to promote attractive teaching and learning sessions.*

The onus is on the DoE to ensure that teachers are trained to manage the transition from traditional teaching methods to incorporate technology in teaching and learning. Often teachers are perceived as being resistant to change and that their attitudes have a significant effect on their decisions to use ICTs. If teachers have a specific viewpoint regarding teaching methods, they will be averse to incorporating technology in teaching and learning. This will have a negative influence on the integration of ICTs in education, and a challenge when such teachers are requested to teach in a paperless context. Age also influences teachers' pedagogic integration of ICTs (Mathipa & Mukhari, 2014; Minty, 2012; Tedla, 2012; Cavas, Cavas, Karaoglan & Kisla, 2009). Studies have shown that teachers, who lack ICT skills or who are close to retirement, feel insecure to incorporate ICTs in their teaching and learning (Minty & Pather, 2014; Minty, 2011; Bingimlas, 2009). This is due to fear of failure and their belief that the learners in the classroom will be more technologically advanced than themselves, consequently, thwarting the incorporation of ICTs in their teaching.

Research conducted in the Western Cape in South Africa, that investigated the factors that motivated teachers to use ICTs in teaching and learning revealed that school policies on the use of ICTs as well as the number of learners allocated to a computer could deter teachers from using technology to teach (Chigona et al., 2014). At these so-called paperless schools, the GDE provided each learner with a tablet and smartboards were installed in classrooms, however, the problem arises when the smartboard is not working or learners forget to bring their tablets to school or the device is either broken, stolen or sent for repairs. In this study, the smartboards not working, and broken, lost or stolen tablets were serious inhibitors to the integration of ICTs in the Mathematics classroom. In addition, because teaching and learning was conducted at these so-called paperless schools, using a combination of technologies, such as the chalkboard/whiteboard, as well as pen and paper, teaching and learning could continue when the use of technology proved to be problematic. However, this would not be the case if teaching and learning were to be conducted in a "truly" paperless context, which would question the

viability of teaching and learning of Mathematics in a paperless context. In addition, a lack of technical and pedagogical support has also been identified as significant for the incorporation of ICTs in teaching and learning.

A Lack of Technical and Pedagogical Support to Integrate ICTs in Teaching and Learning

A pre-requisite for teachers to integrate ICTs in the classroom is the availability of good technical support (Mukhari, 2016; Minty & Pather, 2014; Kler, 2014; Ifenthaler & Schweinbenz, 2013). Ifenthaler and Schweinbenz (2013) added that teachers, who they interviewed, highlighted the need for a sound technical and supportive infrastructure as a pre-requisite for ICT integration to ensure that teaching and learning are not disrupted or halted due to technological problems. Mathipa and Mukhari (2014, p. 1219) stated that

> *… teachers also expressed concern about the technical support. They mentioned that the Department of Education takes long to repair or to replace damaged computers and other ICT tools. Such delays also hamper the progress of both teachers and the learners*.

Teachers are dependent on support from the DoE. However, if this is lacking and teachers have prepared technology-based lessons, *what are teachers supposed to do if the technology is not working?* It is obvious that if technology is not available, they would have to revert to the traditional method of teaching and learning. In these so-called paperless schools, where this study was conducted, the smartboards in several classrooms were not working, consequently, teachers had no alternative but to use the traditional-based method of teaching and learning. Additionally, time is of the essence as teachers have a curriculum to complete. If teachers must focus on resolving technical issues as well as teaching the subject content, they then may be deterred from integrating technology in their classrooms.

Albugami and Ahmed (2015) pointed out that a lack of resources and the maintenance of these resources was another obstacle experienced regarding the integration of ICTs in the classroom. The availability of resources at some schools is negatively affected by either vandalism or theft (Mathipa & Mukhari, 2014). This is an ongoing problem faced by many South African schools. Numerous newspaper articles have published theft of ICTs, not too soon after the DoE provided these to schools. This theft was especially prevalent when paperless schools were established. The findings of this study revealed that the theft of ICTs is a serious inhibitor to teaching and

learning when using ICTs, and more so in a paperless context. The lack of time is another obstacle that discourages teachers from incorporating ICTs in teaching and learning.

The Lack of Time to Incorporate ICTs in Teaching and Learning

Preparation and planning for the use of ICTs in teaching and learning are time consuming according to many teachers (Sicilia, 2005 in Kler, 2014; Minty, 2011). Ainley et al. (2010) stated that a lack of time was cited by principals as an impediment to the use of ICTs in the classroom. Tedla (2012) claimed that in-service teachers indicated that limited time to complete the curriculum was an obstacle to ICT integration. Mathematics teachers from Malaysian schools also claimed that time constraints prevented them from incorporating ICTs in their lessons (Abdullah, et al., 2016). This was a global problem but Australian teachers specifically found it time-consuming to attend training on digital technology and develop lessons that includes ICT activities (Hyndman, 2018).

Apart from preparation and planning for the use of ICTs in teaching and learning, examination pressure has been cited as one of the contributors to the lack of time for the pedagogic integration of ICTs. Teachers are bound by regulatory demands and preparing learners for examinations is a priority. Consequently, they do not have the time to be innovative nor to experiment with diverse methods of teaching, fearing that learners might achieve poor academic results when assessed using the traditional paper-based assessments (European Schoolnet, 2013). Although technology may be used to teach at specific South African schools, irrespective if deemed paperless or not, students will invariably be assessed using conventional paper-based assessments. It is also important to point out that for the use of ICTs to benefit learners and for learning with technology to continue outside the classroom, parent involvement is essential.

Parents' Involvement with Learning

According to Waterford.org (2018) "… *when parents are engaged in their children's school lives, students have the home support and knowledge they need to not only finish their assignments, but also develop a lifelong love of learning*". They believe that it is this level of engagement on the part of parents that accurately predicts learners' academic achievement and not their socio-economic status nor the prestigious schools that learners attend. To an extent,

this is true, however, the socio-economic status of learners does play a crucial role when teaching and learning is conducted using technology. A study conducted at selected urban South African schools regarding ICT-use revealed that teachers claimed that learners do not receive the necessary support from their parents, as a result of poverty and parents not being literate (Mathipa & Mukhari, 2014).

Baytak et al. (2011) found that one of the barriers regarding the integration of technology at home was attributed to the parents' lack of knowledge and experience on how technology is used in the learning process. Because parents may believe that their child is not using the technological device/s for study purposes, they then tend to limit the amount of time that their child spends using the technology. The implication of such an action is that it becomes imperative that communication between the school and parents be increased (Baytak et al., 2011) to explain that the use of technology at home is for educational purposes.

While the benefits of technology use such as, it motivates learning, it allows for the reinforcement of concepts being taught by watching videos and it provides access to additional material that may be sourced from the internet, are acknowledged, various concerns have been highlighted by Shunmugam (2016). This study was conducted at several South African primary schools and focused on the perceptions of parents regarding technology-use. Parents believed that the use of technology was not to replace the teacher in the classroom but rather to enhance the lesson. They believed that the presence of technology should not be taken advantage of and used as a replacement for teaching and learning. Furthermore, parents believed their children would become dependent and addicted to technology. As a consequence, they felt this would have a negative impact on their child's cognitive development and basic skills, such as the correction of spelling errors and the loss of basic mental Mathematical skills. The "spelling and grammar" option is available on most word processors, as well as the calculator application being available on devices, learners tend to rely on these tools to find answers to or correct their work. This over-reliance on technology leads to learners "forgetting" how to spell words correctly, carry out basic computational activities without the use of technology and most of all, forget how to write legibly as these skills are no longer being practiced when technology is at their fingertips. This problem is exacerbated when teaching and learning must be conducted in a paperless context where the use of pen and paper is excluded as expected by the Gauteng MEC for paperless schools. In addition, parents are apprehensive that their children will be

exposed to both prohibited and unsuitable content through the internet and therefore believe that when technology is used, irrespective of the purpose, it is important that these learners are properly supervised all the time (Shunmugam, 2016).

Crime in South Africa is rife. Reports in local newspapers include incidents where school learners are targeted by criminals for their smartphones. With the introduction of technology-use at schools and especially with Gauteng paperless schools, parents are concerned about the safety of their children. Learners become easy targets for criminals as they have to carry their tablets with them (Shunmugam, 2016). Their trepidation is not limited only to the lost or stolen device but extends to the loss of information stored on learners' tablets. In a paperless context, all resources would be on the learner's tablet and unless a backup of the information was made, all information would be lost. However, even though a learner may have a "backup copy" of their resources, they would still require a device to access this information and the costs of replacing a lost, stolen or broken device, as well as maintenance costs, were of concern to parents of South African learners (Shunmugam, 2016).

Technology has a negative influence on learners' abilities to interact socially with their peers. This is evident when families seated in restaurants are engrossed on their cell phones. Technology has dominated learners' lives to such an extent that they have become addicted to these devices and forget to interact socially with their friends or take part in other activities that do not include technology. This over-reliance, excessive use of technology and the addictive nature of technology, are all concerns that parents expressed towards technology-use in schools (Shunmugam, 2016). Despite the various concerns and challenges that have been discussed regarding technology-use in education, it is important to point out that no-one is averse to the use of technology in teaching and learning. However, it is imperative that technology-use is supervised and used appropriately to avoid addiction and over-reliance on them. For this to be achieved both teachers and parents must be involved in the learning process. Consequently, Mukhari (2016) recommended that stakeholders in education should collaborate with parents to provide an ICT infrastructure that will cater to the needs of all learners. Shunmugam (2016, p. 72) added

> *... if we are to increase the relationship between parents and the perceptions they have on technology in the classroom, we need to target the competence of technology use to parents ... technology integration requires collective support for this successful integration to occur. This means that parents' usage and competence must be increased, such that they can aid their children through this introduction of technology in the classroom.*

Another inhibitor to technology use by teachers is the issue of cheating, impersonation and plagiarism during assessments. Although these cannot be eliminated, irrespective of the context within which assessments are conducted, these issues pose a real challenge when technology is used for assessment purposes.

Cheating, Plagiarism and Impersonation

Research indicates that cheating, plagiarism and impersonation are further challenges that teachers must contend with especially when e-assessments are conducted (Minty, 2019; Mellar, Peytcheva-Forsyth, Kocdar, Karadeniz & Yovkova, 2018; Shunmugam, 2016; Eljimini, Alsamarai, Hameed, & Amawi, 2012; Nicol, 2007). Impersonation may not be a major problem if e-assessments are conducted face-to-face as teachers would be able to authenticate each learner in the classroom. However, impersonation becomes a serious issue if assessments are conducted remotely. In 2020, the global lockdown due to the Corona virus pandemic had HEIs suspend all face-to-face classes with students and transition to an online platform overnight, in an attempt to save the academic year. Assessments had to be conducted with students, however, conducting online assessments have raised various challenges that HEIs had no choice but to contend with. Firstly, it is extremely difficult to authenticate who is writing or taking the assessment, resulting in impersonation as a challenge. Secondly, whether assessments are conducted using technology, either remotely or in the traditional face-to-face setting, students are able to cheat. They can reference resources, such as electronic copies of textbooks, their notes, share answers using social platforms such as WhatsApp as well as search the internet for answers. For face-to-face assessments, if the internet is not a necessity for the assessment, then access to the internet could be deactivated for the duration of the assessment. A "lockdown browser" could be used on the learning management system (LMS) so that learners are unable to leave the browser to access other resources or applications. However, if access to the internet is a prerequisite or the LMS is not being used to conduct the assessment, then cheating becomes a major problem that requires teachers to be more vigilant than when paper-based assessments are conducted. This places an additional burden on teachers as it may affect the quality of the assessment and learners may obtain results that may not be a true reflection of their abilities. It is important to point out that cheating is not only of concern to teachers but to parents as well (Shunmugam, 2016). In addition to the problems identified above that influence ICT-use, the lack of ICT policies has also been identified as one of the obstacles of ICT integration at schools.

Lack of ICT Policies

It is imperative that each school should have a policy regarding ICT integration since the lack of ICT policies at South African schools was cited as a major challenge for the successful integration of ICTs (Mathipa & Mukhari, 2014). This finding is supported by a study conducted by Albugami and Ahmed (2015, p. 36) that focused on "*What factors affect the successful implementation of ICT in schools?"* Obara et al. (2018, p. 1347) found:

> *... teachers' conceptions of technology and school policy on technology, had an impact on technology implementation. The impact on technology implementation was largely affected by how the policy encouraged or discouraged the teachers in their efforts to use computing technology (computers and calculators) in their Mathematics teaching.*

Therefore, it is important that when such a policy is designed, it should be realistic, and the school should ensure that the goals as set out by the ICT policy, are achievable. In addition, cognisance should be taken of the diverse factors and challenges affecting each school when designing this policy as a single ICT policy would not suffice and could not be applied to every school because the challenges experienced by each school differ. An example of where a policy should differ was evident in this study where teachers indicated the disparity between the GDE requirements and that of the district officials (see Chapter Seven). Bearing in mind that teachers in this study were "supposed" to be working in a paperless environment, it was evident that there was a lack of communication between the GDE and the district officials as they required paper-based reports and paper-based evidence of learners' work. Considering that these schools are designated as paperless schools, the GDE should have allowed the submission of soft copies of the information. However, when a teacher tried to submit soft copies of the information required, he was accused of "not doing his work" (see discussion in Chapter Seven). What may be inferred is that there is no "clear" policy by the GDE regarding the dissemination of information from paperless schools as required by the district officials. As a consequence of a lack of such policies and poor communication, the above-mentioned teacher became despondent and outraged. The above requirement (paper-based evidence of learners' work) from the district office is contradictory to how teaching and learning should be conducted in a "truly" paperless context. Furthermore, every teacher differs in their teaching style. Therefore, they should be given the opportunity to use the "best" teaching style that they deem most appropriate to teach the subject content. A discussion of the different teaching styles follows.

Teaching Styles

Teachers are faced with the responsibility of teaching learners, each possessing distinct learning abilities. Teachers, therefore, have to seek instructional methods that cater to these diverse learning abilities. As a consequence, they must use varying teaching styles in their classrooms for learners to comprehend what is being taught. Individuals are unique human beings, similarly, teachers are unique regarding the teaching styles they choose to employ in their classrooms. These teaching styles may be dependent upon the mission statement of the school, the philosophical beliefs of the teacher, and the demographics of the learners in the classroom or the school, and most importantly, the discipline. It is therefore important that teachers use teaching styles that are effective, will aid in engaging learners in the lesson, and facilitate the development of critical thinking skills. When selecting a teaching style that will cater to the needs of the diverse learners in the classroom, the teacher must identify his or her strengths and weaknesses. The teacher uses this style to teach a particular content, which will enable them to determine what works best based on personality and the curriculum.

Grasha (1994), a professor of psychology at the University of Cincinnati, identified five teaching styles that dominated the classroom environment: *expert, formal authority, personal model, facilitator* and *delegator*. A description of each teaching style together with the advantages and disadvantages of each is found in Table 3.1 below.

Table 3.1 Five teaching styles (Adapted from Grasha, 1994, p. 143)

Style	Description	Advantage	Disadvantage
Expert	Similar to a coaching style, where an expert (the teacher) shares his or her knowledge and skills, provides advice and feedback to learners to enhance comprehension and promote learning. By displaying this detailed knowledge of the subject, the teacher endeavours to maintain this status of "expert" and is more interested in communicating this knowledge to the learners.	The knowledge and skills that such teachers possess.	This style does not always demonstrate the thought processes that learners applied to arrive at a solution.
Formal authority	Teachers who employ this style incorporate the traditional lecture format. This style has many characteristics of the expert style; however, learner interaction is limited. This style is concerned with the correct, acceptable and standard ways of doing things.	Here the focus is on what is expected from learners and how these tasks must be accomplished.	This style could lead to an inflexible and a homogenous way to oversee learners and their concerns.
Personal model	A teacher employing this style believes in "teaching by personal example". They supervise and direct learners by showing them how to do things, encouraging them to observe how the task could be accomplished and then emulate the approach.	This is a "hands-on" approach, the emphasis is on learners observing the teacher and following a role model.	Since some teachers may believe that their approach is the best, this could lead to learners feeling inadequate if they cannot fulfil the expectations as emulated by the teacher (role model).
Facilitator	Such an approach aims to develop the individual capacity of learners by providing a supportive and encouraging environment. The teacher guides learners by posing questions, investigating possibilities, proposing alternatives and encouraging them to make informed choices.	This style is flexible, the focus is on learners' needs, their willingness to explore alternatives.	This style is time-consuming and can be unproductive when a more direct method is required. If not used in an encouraging way, learners can become quite uncomfortable with this style of teaching.
Delegator	This teaching style aims at developing learners' abilities to work autonomously. Here learners work independently or in groups.	Learners see themselves as independent learners.	All learners may not be receptive to this teaching style and may become anxious when given autonomy.

Grasha (1994) cautioned against distinguishing or placing teachers into a single category since they assume various roles in the classroom and consequently, believed that many teachers possess a combination of the above-mentioned teaching styles. Teachers must take cognisance of Grasha's (1994) advice: before deciding how to deliver the content, teachers should consider several factors, such as learners' diverse abilities, the content to be learned, which technology would suit the delivery of the content as well as the classroom infrastructure, to name a few.

Having established the above factors it is then incumbent upon the teacher to choose the teaching styles that are best suited to deliver the subject content.

There does not seem to be consensus on the diverse teaching styles that teachers employ in the classroom as is evident in the discussion that follows. Thornton (2013), a trainer and professor at Springfield Technical Community College, Massachusetts believed that teaching styles can be grouped into the following three categories: *delegate, discuss* and *direct* as shown in Figure 3.3 below.

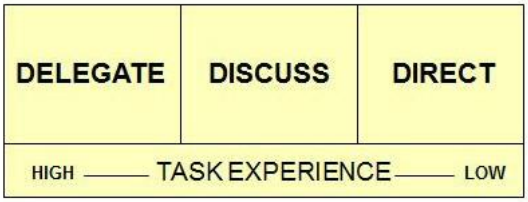

Figure 3.3 Three Teaching Styles (Thornton, 2013)

The *direct* style involves the teacher telling learners what needs to be done, how it must be done and when it must be done. Learning using this style is accomplished through learners listening and following the directions of the teacher. This method is synonymous with the lecture method. The *discussion* method, on the other hand, encourages learning through critical thinking, there is active learner participation and the teacher takes on the role of a facilitator. Using the *delegating* method, the teacher empowers learners to either work individually or in groups on a particular task.

Welcome (n.d.) conversely categorises teaching styles into the following six categories, namely: *teacher-centered, technology-based, student-centered, relaxed teaching style, flipped classroom* and *facilitator-in-chief.* According to Welcome (n.d), the first teaching style mentioned is "*teacher-centred*", which is regarded as the old-school teaching style where it is the teacher, who is seen as the expert in the classroom and disseminates information to learners either in a lecture format or some form of direct instruction. With this teaching style, there is limited learner engagement or discussion. Despite this method not being favoured, it still has its place in the classroom and in certain instances, it can be an extremely effective method, if approached correctly.

The second teaching style is called "*Technology-Based*", where almost everything that the teacher does is related to some kind of technological resource (Welcome, n.d.). The third teaching style is "*Student-Centred*", where both the teacher and learners interact with one another in the classroom. However, the teacher is still the authoritative figure but takes on the role of a facilitator. This method increases learner engagement in the classroom as group work is encouraged, and communication and collaboration amongst learners increases. This could, however, make the classroom extremely noisy and challenging to manage. The fourth teaching style is the "*relaxed teaching style*", which lacks any type of formal structure.

The fifth teaching style is that of the "*flipped classroom*" where the teacher may use videos that learners have to watch before attending the lesson. Alternatively, the teaching may be delivered online or outside of classroom environment. It is important to point out that a flipped classroom does not eliminate teaching by the teacher but instead, it is a way to prepare learners before the actual learning experience. The sixth and final teaching style is that of "*facilitator-in-chief*". This style is an amalgamation of selected parts of each of the teaching styles. Here the teacher would introduce the lesson to the learners and thereafter, learners are encouraged to proceed on their own. Teachers that use this style are aware that one teaching style cannot be used to teach every learner. It is evident from Grasha's (1994) discussion of teaching styles that Welcome (n.d.) concurs that a "one-size-fits-all" teaching style approach is not ideal.

No teaching style is superior; however, teachers must take cognisance of the diverse learners that they have in the classroom and use different teaching styles to cater to the needs of the individual learners. For teaching and learning to be effective, it is important that a teacher not be characterised by a particular teaching style but should use a variety of styles to construct learning since "… *the most effective teachers vary their styles depending on the nature of the subject matter, the phase of the course, and other factors. By so doing, they encourage and inspire students to do their best at all time*" (Thornton, 2013, p. 1).

Teaching styles are influenced by PK, a component of TPACK, and therefore, Efilti and Çoklar (2013, p. 355) claim that "… *a meaningful relationship between TPACK education competence and teaching style emerges between the two*". From the above discussion, it is apparent that when one should or should not integrate technology and to what extent to integrate technology, is largely dependent upon teachers' teaching styles. Thus far, references have been made

towards two teaching environments, the traditional teaching environment where the chalkboard/whiteboard, exercise books and pen and paper are used and the paperless context which is devoid of the use of pen and paper. The combination of the chalkboard/whiteboard, exercise books, pen and paper as well as technology results in a blended teaching and learning environment which is discussed next.

Blended Teaching and Learning Environment

The term "blended learning" is an approach where various methods can be used to enhance the teaching and learning process. This could be the combination of technology, online educational materials as well as the traditional face-to-face method of teaching and learning. Since learners vary in learning abilities, the blended approach offers teachers the opportunity to present the subject content in different ways, while catering to the diverse needs of learners. Furthermore, blended learning may allow learners to work at their own pace to achieve their individualised goals (Harris, 2017). Allen (2017) added "*It's instilled independence, confidence and a new passion for learning for many of our students*". An example of a success story of blended learning as presented by Allen (2017) is where a learner in her class chose to participate minimally in lessons as she was afraid of "showing off". Her teacher added *"... she would never showcase her depth of understanding or knowledge in front of her peers. She was always willing to help another child if they needed it, but she would quickly deflect any praise" (*Allen, 2017). However, this learner's self-confidence grew as soon as blended learning was introduced as she began to participate in class. The learner became more comfortable with her academic capabilities and more importantly, she believed in her abilities as she participated more regularly in class, sharing her opinions and demonstrating her abilities (Allen, 2017).

According to Horn (2014) schools that have implemented blended learning models have shown great improvements in Mathematics and reading results. The perception is that the onus upon creating and implementing a blended learning environment lies with the teacher. However, research indicates that a supportive environment is necessary and crucial to the successful integration of technology (Aziz & Shah, 2015; Chan, 2015; Howard et al., 2015; European Schoolnet, 2013; Ainley et al., 2010). Horn (2014) concurred "… *if teachers feel well supported and prepared by administration, they will feel more on board with the transition*". When teachers are mandated to integrate technology in the classroom, teachers, who lack self-

efficacy, may become overwhelmed. It is therefore, important that teachers be allowed the time to transition to this new context of integrating technology in their classrooms as well as be provided with the relevant and continual training to develop their skills. Therefore, a blended teaching and learning environment would be most suitable as it would allow teachers to choose when to integrate technology in their lessons based on their teaching styles, the subject content to be taught and their technological abilities. In a "truly" paperless context, however, teachers would not have the choice as to when to employ technology in their lessons because, according to the MEC, all teaching and learning in these classrooms must be accomplished through the sole use of technology. Demanding the context (paperless) within which teaching and learning must be constructed may be catastrophic, especially in South African schools, as the discussion throughout this chapter points out the various challenges that exist at these schools.

A study conducted by Porter et al. (2020) which focused on the experiences of academics who implemented the BOLD (Blended Online Digital) approach to teaching and learning, indicated that despite these academics being experts in the subject matter being taught, they lacked the expertise to implement the BOLD approach. The participants from Porter et al.'s (2020, p. 11) study pointed out that because there were no guidelines as to how to implement the BOLD approach as well as "*things kept changing*", they found it extremely challenging to implement. In addition, the participants cited not having adequate time to prepare and revise their work before implementing it, as major obstacles. They indicated that "… *the senior leadership of the institution were not aware of the time involved in the development of content, and learning design initiatives*" (Porter et al., 2020, p. 12). A supportive environment is integral to ICT integration; if the necessary support is not available as experienced by the participants in Porter et al.'s study, this may prevent teachers from implementing technology. As discussed earlier in this chapter, there are numerous barriers to the successful integration of technology in the classroom, such as the age of teachers and their resistance to change. To overcome these barriers, these changes must be introduced over time, allowing teachers and learners to adjust to technology use. By providing constant, suitable and relevant training as well as providing continual and expert support at schools, the barriers of self-efficacy and resistance to change may be overcome. Since this study focused specifically on the teaching and learning of Mathematics, a discussion on the pedagogic integration of technology in Mathematics follows.

The Pedagogic Integration of ICTs in Mathematics

Various tools may be used to enhance the teaching and learning of Mathematics. Some of the most commonly used tools include the calculator, spreadsheet programmes, Geometer's Sketchpad and GeoGebra, to name a few. However, it is important that when teachers use these tools, they ensure that they are used in such a manner that it does not replace learner thinking, but rather promote it. For example, the use of the calculator in Mathematics makes the learner's task an easier one. However, the negative aspect is evident when learners have to write the National Benchmark Tests (NBTs), which is a prerequisite for entrance into certain qualifications at South African HEIs. The use of a calculator is strictly prohibited when writing the NBT tests for Mathematics. Having a daughter who completed Grade 12 in 2019 and who was required to write the NBTs, it was necessary for her to re-learn how to answer Mathematical questions without the use of a calculator. As a result, she had to attend additional tutoring sessions in Mathematics to be taught how to solve Mathematical problems using pen and paper for her to attain the requisite skills to write the NBTs and to perform well. Considering that the NBT assessments are requirements set by the South African educational authorities, it is questionable as to why the GDE would promote teaching and learning in a paperless environment, especially when technology, a calculator in this case, may not be used in NBT assessments, just to name one. Lolli (2012) concurred as teachers in her study believed that the over-use of the calculator was considered detrimental to learners' acquisition of specific Mathematical skills. This, in my opinion, is a contradiction and places learners at a disadvantage since universities are operating in a blended teaching and learning environment, where the use of pen and paper is still being used extensively for assessments.

There is no doubt that technology should be used in the classroom, however, the fundamental issue is: *Must teaching be conducted in a paperless context*? Is the context (paperless) that important, why not a blended environment where both teachers and learners can benefit from the use of pen and paper (as in the case of NBT assessments) as well as the use of technology? Similarly, when using other tools, such as spreadsheets and GeoGebra, it is important to take cognisance of the above discussion because if the tool is taken out of the "equation", then the learner would not be able to carry out those Mathematical activities that were taught to them solely with the use of technology.

Teachers believe that the use of technology and software is beneficial to the teaching and learning of language, Science and Mathematics as is evident below:

> *… language, science, and Mathematics teachers share similar attitudes towards the use of ICT in schools. They all agree on the positive impact of ICT on students' higher-order skills, and they agree with the statement that ICT should be used for students to do exercises and practice, retrieve information, and work in a collaborative and autonomous way* (European Schoolnet, 2013, p. 2).

In addition, teachers who use technology and software were enthusiastic because learners were able to engage with the visuals provided by the software (Lolli, 2012). However, Lolli (2012) found that although technologies and software benefitted learning in Geometry, teachers in her study indicated that technology was not necessary. This, therefore, begs the following question: *What is the viability of teaching and learning Mathematics in a paperless context if some teachers in paperless schools share the beliefs of Lolli's (2012) participants?* A similar study conducted by Tatar (2013) on Mathematics teachers' perceptions of the use of software to teach, indicated that their perception levels regarding technology were raised and that the use of software had a positive effect on teaching and learning. The participants in Tatar's (2013) study indicated that the use of technology-facilitated and stimulated learning, increased retention and presented learners with an engaging and fun classroom environment.

Math Shelf (Mathematics curriculum offered on a tablet) was used by public-funded preschools in Los Angeles, USA, in an attempt to improve Mathematics achievement of preschool children. Research had indicated that children from low-income areas demonstrated a lack of Mathematics knowledge when they entered kindergarten (Schacter & Jo, 2016). The study of two hundred and seventy-three children at thirteen of these public-funded preschools over fifteen weeks, was investigated to establish the effect of employing Math Shelf (Schacter & Jo, 2016). The group included pre-school children, who studied Mathematics using Math Shelf, while the remainder studied Mathematics following the normal curriculum. The findings indicated that children who used Math Shelf gained a year of additional Mathematics knowledge, compared to those who attended the normal Mathematics curriculum, did not (Schacter & Jo, 2016).

Marrades and Gutiérrez (2000) and Straesser (2001) as cited in Özen and Köse (2013) posit the view that the use of software to teach Mathematics offers learners the opportunity to easily experiment. When drawing graphs using software, students may manipulate the data and

immediately see the changes reflected, as opposed to a pen and paper environment where such a task would be laborious. In addition, the move from concrete to representational and abstract activities is claimed to assist learners experiencing learning difficulties to comprehend and grasp Mathematical concepts (Allsopp, Kyger & Lovin, 2007 in Bate et al., 2013). Despite the various benefits of using technology in the teaching and learning of Mathematics, teachers in Lolli's (2012) study believed that the excessive use of technology, especially in the teaching of geometry in Mathematics was not beneficial to learners as they lacked the confidence to solve the problems manually, and consequently, relied on the use of technology to do so. They claimed that learners might not understand how to solve the problem with the use of technology, as they do not see the steps that one would follow but would only see the final answer. They also maintained that certain concepts should be taught using the traditional method and only once learners have a thorough understanding of the concept, should technology be introduced to explore the concept further.

A study conducted in rural Peru that investigated the impact of the OLPC project, fifteen months after implementation, revealed that although the project succeeded in increasing the number of devices (laptops) available to learners, neither Mathematics test scores nor language scores were influenced by the use of technology (Cristia, Ibarrarán, Cueto, Santiago, & Severín, 2012). Other research indicated that despite extensive investments in technology, internet connections and software, there is a paucity of concrete evidence that the extensive use of technology improves learners' results in either Mathematics, Science or reading (OECD, 2015). Instead, the results of the study indicated that learners from countries that did not use technology or the internet, often improved their performance by reading rapidly and at a faster pace compared to those in other countries, where the use of technology in the classroom is an everyday occurrence. Furthermore, the report (OECD, 2015, p. 154) stated "*Across OECD countries, students who do not use computers in mathematics lessons tend to perform better in the paper-based and the computer-based assessment of mathematics*".

The research conducted by the OECD (2015) is of significance as the GDE had estimated the transition to paperless schools to be a cost of R17 billion by the end of the 2017/2018 financial year (Falanga, 2015). Considering the results of OECD (2015) and that the extensive investment in technology does not improve learners' results in Mathematics, Science and reading, the question is whether the intended investment of R17 billion by the GDE will make

any difference in learners' Mathematical skills and subsequently, their results. This is substantial expenditure that the Government has earmarked for the paperless school initiative even though there is very little concrete evidence that the use of technology in teaching and learning has a positive influence on learners' results. Consequently, this intended study is relevant and timely as it may produce results that either support or refute the findings of the OECD (2015). It is reasonable to assume that if Mathematics is taught in a paperless context, then learners' abilities and understanding of the Mathematical content should be assessed using technology. It is therefore important to discuss how assessments should be conducted specifically in Mathematics, as this study focused on the viability of teaching and learning Mathematics in a paperless context.

Assessment in Mathematics

Assessment, which forms an integral part of education, where teachers can gauge the extent to which learners have gained the necessary knowledge and skills, becomes a simpler process with the use of assessment software. In this regard, ICTs could assist teachers to develop innovations in e-assessment, which has the benefit of providing learners with instantaneous feedback, allowing learners the opportunity to take corrective measures immediately to improve their learning (Wang, 2011). When there are large student numbers, and time constraints to provide assessment results to students and other stakeholders, e-assessments have proven to be valuable (Minty, 2019). With e-assessment tools, the compilation of assessments becomes an easier process as questions are simply selected from a pool of questions (database), thus reducing the workload of educators/teachers (Minty, 2019). The use of e-assessment tools (such as an LMS), where multiple-choice, matching, true or false and complete the statement questions, just to mention a few can be compiled, also provide automated marking of assessments, further reducing the workload of teachers. However, despite the above-mentioned benefits of using e-assessments, educators/teachers must be wary of the various challenges associated with these.

Firstly, the issue of cheating, impersonation and plagiarism as discussed earlier, poses questions on quality assurance as well as the authenticity of the assessment. Secondly, the issue of internet connectivity, data, as well as access to devices such as laptops and computers, continue to be problematic. If downloads are slow or interrupted the student/learner would not

be able to complete the assessment, resulting in a lower mark. There are, however, contingencies that may be applied in such situations, for example, when the student/learner provides evidence of the problem experienced, they could be re-assigned another assessment. But then this does not solve the problem and if the same problem/s persist in the second attempt, then once again quality assurance will be negatively affected because the student/learner will have to be provided with more attempts/assessments. This could become quite frustrating to the affected student/learner due to the various problems as well as being unfair to others who only had one attempt at the assessment. In addition, the workload of the teacher increases as they would have to design new assessments for the affected students.

Thirdly, the type of questions found in the database or that may be compiled with e-assessment tools, including LMSs, are of concern because these questions are simply level 1 to 3 questions, according to the revised Bloom's taxonomy (Figure 3.4 below).

Figure 3.4 Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001, p. 1)

Level 1 (remembering) focuses upon the learner's ability to recall previously learned facts or concepts. Level 2 (understanding) expects the learner to express an understanding of the concepts learned by organising, making a comparison of and interpreting pieces of information. Level 3 (applying) requires the learner to apply the knowledge they have gained to solve problems. Level 4 (analysing) necessitates the learner to interrogate the information to formulate conclusions and to find evidence to support the generalisations they arrive at. Level 5 (evaluating) involves the formulation of opinions, however, these opinions must be supported by evidence. Finally, level 6 (creating) involves the development of new ideas or solutions. Therefore, when assessments are designed, teachers need to take cognisance of these different levels of questioning and employ them in their assessments. Regarding the use of technology

to conduct assessments, it is the level of difficulty of the questions that may be constructed using these tools that are of concern. It is difficult or not possible to assess higher-order thinking skills using such tools as most of the questions found in the available e-assessment software, focus on multiple-choice, true-or-false, fill in the blanks and matching type of questions. This is a major challenge as expressed by the participants of this study (see discussion in Chapter Seven).

Considering the above discussion, it is important to note that at times, the sole use of technology in teaching and learning may be disadvantageous to learners (see discussion on NBTs under "The Pedagogic Integration of ICTs in Mathematics"). For both teachers and learners to use the technological device for assessment purposes, they would have to be proficient regarding the use of the selected e-assessment software and technological device. Without a doubt, e-assessments can be conducted and are useful, however, the problem stems from all assessments being conducted electronically, where the issue of quality, security and authenticity arises.

The use of technology for assessment purposes may not always be beneficial to learners. Aakre (2017) in Minnesota, USA investigated the effect of implementing a paperless assessment in Biology at a secondary school. The findings indicated that "… *overall, the students performed significantly better in a paper format over digital … Low achieving students performed significantly worse on digital assessments compared to paper assessment*" (Aakre, 2017, p. vi). Perhaps this may be the reason why most teachers and learners from this study preferred a blended learning environment compared to a paperless one (see Chapter Five).

Furthermore, Obara et al. (2018, p. 3348) assert that "… *the policy about the assessment plays a key role in whether technology is used in the classroom [or not]*". What may be inferred from the above-mentioned statement is that if assessments are conducted using pen and paper, teachers may be less inclined to use technology in the classroom and vice versa. Despite the article by Wall (2000) being 20 years old, the following advice is valuable "… *under the right conditions and with proper use, a marriage of technology and assessment can shine like a diamond. Used without proper care and forethought, however, it can be a rock*". Considering that the discussion thus far has focused mainly on the integration of technology in teaching and learning, irrespective of the context (paperless or not), the discussion that follows focuses

specifically on the viability of teaching and learning in a paperless context and, where relevant, on Mathematics.

The Viability of Teaching and Learning in Paperless Classrooms

To re-emphasise, there is a paucity of scholarly articles on "truly" paperless classrooms globally, however, there is an abundance of anecdotal evidence on schools that claim that they are paperless. Despite these schools claiming to be paperless, there is evidence that these classrooms are not operating in a "truly" paperless context. Teachers claimed that assessments using technology, is restrictive since the type of questions that could be compiled are limited to multiple-choice questions, fill in the blanks, true or false and matching questions (see discussion in Chapter Seven), consequently, they resort to the use of pen and paper for examinations and tests, and to prevent cheating.

Ifenthaler and Schweinbenz (2013) revealed that only a small number of participants believed that the use of technology would improve teaching and learning. Most of the participants were uncertain on how Tablet-PCs could be used as pioneering tools to enhance teaching and learning. One needs to bear in mind that to teach and learn in a paperless context, teachers and learners need to believe that the use of technology in the classroom is beneficial, otherwise it will not be possible to go paperless if there is resistance in any form. Furthermore, this acceptance or rejection regarding the use of technology will inevitably lead to the acceptance or rejection of paperless classrooms.

To repeat, despite having conducted an intensive search for academic articles on paperless classrooms, limited information was found, however, considerable information was found on the use of technology in teaching and learning. Information sourced highlighted the use of technology in conjunction with traditional methods of teaching. Since there is such a dearth of literature on paperless classrooms, this study will contribute to the current limited literature on teaching and learning in a paperless context. The Gauteng MEC believes that paperless classrooms are feasible and a solution to the education problems in South Africa, consequently it is essential to take cognisance of the advantages and the challenges of teaching and learning using technology, and more so in a paperless context. Kupetz (2008) from Crummer Graduate School of Business at Rollins College in Winter Park, Florida, who taught a course "*Managing*

Technology" in an almost paperless environment, believed that teaching and learning in a completely paperless environment is not possible because in some situations the use of printed material is more suitable than the use of digital material. Kupetz (2008) believed that there are definite advantages to using technology in teaching and learning, which are: learners can submit assignments online, it is easier to carry a tablet around rather than a bag of books, many learners may access one copy of an electronic document which has been uploaded by the teacher on the local network, at the same time, instead of each learner having their own hardcopy, and the visual appeal of an electronic document is enhanced using technology instead of a monochrome printed document in hardcopy (Rutson-Griffiths, 2014; Robb, 1997).

Despite the many advantages offered by the use of technology, Kupetz (2008) experienced two disadvantages that were: firstly, considering that he was teaching at a college where students usually sell their hardcopy textbooks once they have completed the course, students in his class complained that they were unable to do so with electronic textbooks and as a result, were unable to recoup some of their expenses. Secondly, students indicated that *"... they hated reading the e-book on their laptops and printed it out anyway*". However, despite these two disadvantages, he believes that he would continue to teach in such an environment (almost paperless) due to the various advantages that the use of Web 2.0 tools offer. He cautioned that the term "paperless" just meant the reduction in the use of paper and not the complete elimination of paper, which is contrary to how the MEC expects teaching and learning to take place in the "so-called" Gauteng paperless schools.

To re-emphasise, the MEC's statement to the press, "… *we are officially burying the chalk board, we are officially burying the duster, we are officially burying the chalk. Gone are the days when they have to write in exercise books and hand in the assignment*" (see Chapter One) is quite clear that the context that the MEC refers to is one devoid of the use of pen and paper. Kupetz (2008) pointed out that when he chose to employ an "almost" paperless environment to teach his course, the "paperless classroom" was not the goal, but rather the goal was to take advantage of ICTs that would assist in reducing printing costs, to enable easy distribution of study material as well as to facilitate and enhance learning. I concur with Kupetz (2008) since not all content can be taught using technology and there may be various other techniques or methods that may be used to accomplish learning that does not necessitate the use of technology. In addition, as discussed earlier, not all teachers and learners are technologically

savvy. As teachers have a curriculum to complete they would be more amenable to situations where they are allowed the flexibility to choose how to teach the content of a particular subject and when to employ the use of technology. Being forced to teach in a paperless context with the sole use of technology, could be disastrous to teaching and learning, and the intention of introducing technology in South African classrooms to improve teaching and learning, would be thwarted. A study conducted by Padayachee (2017) that aimed at examining the extent to which ICTs were being implemented in South African classrooms, revealed that ICT integration had been hampered by operational, strategic as well as pedagogic challenges. She added:

> *… the uptake of technology remains low, on average the frequency of usage per tool type was as follows: contextual tools (41%), sharing information and ideas tools (29%), experiential tools (26%) and reflective dialogue tools (18%). It was found that teachers are uncertain with respect to the enforcement of e-education while being encumbered by poor infrastructure and lack of skills* (Padayachee, 2017, p. 1).

The following authors, Padayachee (2017), Mathipa and Mukhari (2014) as well as Chigona et al. (2014) provided evidence of factors that are currently inhibiting the use of ICTs in South African classrooms. Taking cognisance of the fact that these studies were not conducted in paperless classrooms, but classrooms where teachers are encouraged to implement ICT-use where necessary, *how then could the MEC expect teaching and learning to be conducted successfully in a "truly" paperless context?*

Many educators, who have attempted to provide a so-called paperless context, have encountered several problems. The lack of adequate training is at the top of the list since training is essential for the effective use of technology. According to Rutson-Griffiths (2014) teachers received three-hour-long sessions but the pace of lessons was slow because both learners and teachers had to familiarise themselves with the material on their devices. In addition, although online submission of assignments is mentioned as an advantage, it is important to note that the submission of these using an iPad is not an easy task, when compared to submitting an assignment using a computer (desktop or laptop) or the convenience of using a Universal Serial Bus (USB) and Secure Digital (SD) card slots, which are available on various Android devices (Rutson-Griffiths, 2014). The human aspect is reduced in a paperless context as there is limited face-to-face interaction, some learners may not have internet access at home because of financial challenges or may not be able to purchase technology or resources required for a paperless environment.

Stuebner (2016) conducted a study of undergraduate students to investige the effect that teaching and learning had on student engagement, in a paperless classroom. In this case, the environment was "truly" paperless as neither pen nor paper was utilised and all activities were conducted online. Despite using a mixed-method approach, the focus was primarily on the qualitative data collected, as the data from the pre-surveys and post-surveys was statistically inconsequential, which was attributed to the length of the study, being over four (4) weeks. Interviews were then conducted with four (4) students, who were selected using a random number generator. The numbers used were those that were assigned to students before undertaking the study. Initially, there was consensus among all four (4) students that they preferred the paperless environment and they cited reasons, such as: they found the classes to be more fun, it was exciting to use technology as all their other classes were paper-based and finally they were able to play games or be engaged in activities that could not be accomplished using paper. However, despite the excitement that the use of technology afforded the students as well as their preference for a paperless context, three (3) of them indicated that they were able to focus better in the paper-based assessment. What is significant is that this finding was analogous with that of the quantitative results. If students cannot focus in a paperless environment despite enjoying the use of technology in the classroom, then this lack of focus would influence student engagement in the lesson (Stuebner, 2016). When questioned on how technology should be implemented in the classroom, there was consensus amongst the participants interviewed that they "… *wanted a choice between [a] paper and paperless classroom*" and one participant added *"… choosing paper or paperless keeps things exciting"* (Stuebner, 2016, p. 16).

Another student from Stuebner's (2016, p. 16) study pointed out that *"I think I focus better when it's on paper for homework...because then I have something I can hold to remind me to do it"*, despite them previously indicating that they preferred a paperless classroom. Another participant indicated that although she preferred the paperless context, she would have liked to have the option to complete her assignments or homework on paper as she spent most of her time at her father's workplace and because they usually arrived home late, she believed it would be too late to work on a computer. The above discussion demonstrates that a "one-size-fits-all" approach to teaching and learning may not be acceptable to all. It is evident that despite some of the participants in Stuebner's (2016) study initially stating their preference for a paperless context, they also indicated that at times they would prefer to use paper. This is indicative that

a blended teaching and learning environment is most suited to teaching and learning as it caters to both types of learners, those that prefer paper as well as those who prefer technology. These findings are significant since it provides evidence that students/learners would like the choice of whether to learn in a paperless or paper-based context and echoes the sentiments of the majority of the participants in this study, who indicated that they preferred a blended teaching and learning environment.

Summary

Various factors contribute to the successful use of technology in teaching and learning and there is definite support for the integration of ICTs in the education process as the belief exists that the use of technology is beneficial to both teachers and learners. However, the literature shows that the successful integration of ICTs in teaching and learning is deeply rooted in teachers' self-efficacy beliefs (Mahdum et al., 2019; Courtney, 2017; Sahin, Celik, Akturk & Aydin, 2013). This view is supported by Gonzalez and González-Ruiz (2017), who maintain that in addition to teachers' beliefs, TPACK plays a crucial role in teachers effectively integrating ICTs in the teaching and learning of Mathematics.

Furthermore, the training that teachers receive both as in-service, and as preservice teachers, should focus on how to use pedagogical practices to integrate technology to teach the subject content so that learning may be enhanced. Sahin et al. (2013, p. 113) added that:

> *… preservice teachers, who have higher levels of knowledge in technology, content, and the integration of these two domains, have high self-efficacy beliefs in the educational use of the Internet… technology, content, and technological content knowledge domains are statistically significant predictors of preservice teachers' self-efficacy beliefs in educational Internet use.*

Messina and Tabone (2013) investigated the proficiency of preservice teachers to integrate technology as well as their TPACK and beliefs regarding the value of integrating technology in teaching and learning. They found that despite preservice teachers displaying high levels of proficiency regarding general technologies such as email and word processing programmes, they displayed lower levels of proficiency regarding the use of technologies such as the interactive whiteboard and software to teach specific subjects. With regards to TPACK:

> *… the participants reported relatively 'higher' scores in CK-content knowledge, PK-pedagogical knowledge, PCK-pedagogical content knowledge and TK-technology knowledge, where technology was not connected to disciplinary contents and relatively 'lower' scores in integrated knowledge domains, namely TPK-technological pedagogical knowledge, TCK-technological content knowledge (in this domain can be counted the impaired aspects of proficiency with dedicated*

> *technologies), and TPACK-technological, pedagogical and content knowledge* (Messina & Tabone, 2013, pp. 25-26).

The findings from Messina and Tabone's (2013) study highlighted the need for teacher training institutions to streamline training programmes to focus on the integration of specific technology within specific disciplines. Koehler et al. (2007), as well as Niess (2006), advocated that the three levels of knowledge domains, CK, TK and PK, are interdependent and therefore, cannot and should not be dealt with separately. The findings from Sahin et al.'s (2013, p. 114) study that "… *knowledge types in technology, pedagogy, content, and their connections are significantly correlated*" supports Koehler et al's (2007), as well as Niess's (2006) claims.

Despite Ngwane and Mbatha (2017) citing numerous benefits of ICT integration such as: it improves the working conditions of teachers, ICTs enable teachers to communicate, collaborate and allows teachers to apply teaching methods that combine the traditional method of instruction and the learner-centred approaches (blended environment), their study revealed that for ICT to be effectively integrated in the classroom, teachers needed to obtain effective professional development and support. They advocated that the school should focus upon providing training to teachers that combine effective pedagogic strategies and ICTs to enhance teaching and learning since suitable professional development is the key to successful and effective ICT integration in the classroom. This view is supported by Umugiraneza et. al. (2018):

> *… teachers who attend workshops are more likely to use technology in their instructional practices than those who do not; hence, interventions that aim to increase the use of ICT in schools must be accompanied by continuous support. It is the support through workshops that will enable teachers to develop confidence in using technology and this may lead to more progressive attitudes by school management regarding the use of computers in classrooms… Any intervention that involves provision of technological resources such as internet access, mobile tablets or laptops will need to be accompanied by the relevant teacher professional development training courses, as well as training and sustained support for using and maintaining the infrastructure.*

The study conducted by Courtney (2017) concluded that the use of ICTs in the classroom should improve learner's academic performance and classroom engagement, and that the achievement of positive results is dependent upon the self-efficacy and continual training of teachers. However, what Courtney (2017) failed to add is that the learner is also an important component that influences academic achievement. If the learner does not use the technology appropriately or fails to put in the effort to achieve better results, the use of technology will not be beneficial.

Teacher “buy-in” is crucial for the successful integration of ICTs. If a teacher does not “buy-into” the idea that the use of technology will benefit teaching and learning, to expect such a teacher to attend ICT training sessions or to integrate technology in their practice, would be futile. This “buy-in” becomes more difficult in the case of paperless classrooms where teachers are expected to only use technology. As teachers are in control of what happens in the classroom, especially with regards to how teaching and learning of the subject content should be executed, it would be reasonable to assume that the teacher would also like to have control over when and how to implement technology in the lesson.

The use of technology should not be an imposition for the teacher, rather the decision should be left to the teacher as to when and how to integrate technology in teaching and learning. This decision would once again largely be dependent upon the teacher’s self-efficacy and technological expertise. Consequently, having a paperless environment, where technology is used solely for teaching and learning is choosing a “one-size-fits-all” context. If a teacher does not “buy-into” the idea of technology integration, its effectiveness and purpose would be diminished especially if the teacher is just integrating technology because it is mandatory to do so. From the discussion in this chapter it is evident that teachers at South African schools are experiencing major challenges regarding ICT integration in their specific disciplines. If teachers are experiencing challenges that inhibit the successful integration of ICTs, when ICT integration is not compulsory but recommended, it would be reasonable to assume that teaching and learning in a “truly” paperless classroom would not be viable and sustainable.

Having presented the literature pertaining to technology-use in the classroom as well as the paperless context, the next chapter presents the methodology that was used to conduct this study.

CHAPTER FOUR

THE RESEARCH DESIGN AND METHODOLOGY

Introduction

This chapter discusses the methodology used and justifies the use of a qualitative research method as most appropriate for this study. Thereafter, the research design, the methods of data collection as well as the data analysis procedures are presented. A qualitative study helps the researcher understand the behaviour of participants in their environment, that is; data is collected by conversing with the participants as well as observing their behaviours at the sites where they experienced the topic being investigated (Neuman, 2014; Creswell, 2013; Henning, Van Rensburg & Smit, 2004). A description of the sites, where the investigation was conducted, is presented later in the chapter. Multiple case studies were identified for use in this study, where data were collected from a selection of participants from four sites. The qualitative research method allowed me to delve beneath the surface of the participants' words and consequently, unearth rich, thick information to answer the research questions. Finally, the ethical considerations are discussed in-depth. To justify the selection of a qualitative research design for this study, it was necessary to compare the quantitative and qualitative research methods.

A Comparison of the Quantitative and Qualitative Methods

There is considerable dissension between proponents of the qualitative and quantitative methods as evidenced by the abundant literature (Patton, 2002; Denzin & Lincoln, 1994; Guba & Lincoln, 1990; Creswell, 1998; Fetterman, 1988). Quantitative research places emphasis on the collection of statistical data and provides a scientific perspective of the research (Neuman, 2014). A positivistic approach is used by quantitative researchers, who rely predominantly on a technocratic approach, where variables and the testing of hypotheses play a key role in the research procedures. When using quantitative methods, the precise measurement of variables and the testing of hypotheses is emphasised, which is related to broad causal explanations (Neuman, 2000; Denzin & Lincoln, 1994). This dissension between qualitative and quantitative researchers has resulted in an ongoing debate that concerns the qualitative and quantitative methods and impacts the way research methods are used.

A survey of the literature pertaining to this debate, confirmed the value of using qualitative approaches and procedures for this study (Patton, 2002; Neuman, 2000; Vulliamy, Lewin & Stephens, 1990). The quantitative method focuses on scientific enquiry that makes use of specific methods for data collection, which involve quantity, number, measurement and rate of occurrence. Data are subsequently used to prove or refute theories (Neuman, 2000). It is important to state that data can be quantitative, which is numerical, or qualitative, which is conveyed using words, pictures or artefacts (Neuman, 2006; Neuman, 2000). However, due to the data collection techniques used in qualitative research, several quantitative researchers question whether social research is scientific or not. Collins (1989 in Neuman, 2014) contends that the dispute regarding whether social science is in fact, a 'science' emanates from the rigidity of the definition of science. However, the understanding of 'science' in social science research is not a conventional understanding of science. Social science research is considered as "soft science" that comprises the study of human beings, such as their behaviours, their attitudes, opinions and their experiences (Neuman, 2006).

The reason for referring to social science research as a "soft science" is that these characteristics of human beings are difficult to measure accurately with "laboratory instruments" or instruments used by quantitative researchers, due to the fluidity and formidability of "*human social life*" (Neuman, 2006, p. 7). Positivists negate qualitative research and claim that the work of qualitative researchers is a fabrication of the truth which cannot be verified or validated (Denzin & Lincoln, 2013). Qualitative researchers contest the above viewpoint of positivists and add that validity, when used in qualitative research, refers to the process of verifying the researcher's interpretation of the data with the participants of the study (Creswell, 2014; Strauss & Corbin, 2008). Creswell (2014) claimed that there is alternative terminology that applies to qualitative validity. These terms are; trustworthiness, authenticity, credibility, and transferability, because qualitative research methods emphasise the personal connection between the researcher, the phenomenon being studied as well as the context within which the study is conducted. In addition, qualitative researchers attempt to search for answers that emphasise how the social experiences are shaped and their implications (Barbour, 2014; Denzin & Lincoln, 2013).

This study involved a change in context from the traditional classroom of pen and paper to a paperless environment using ICTs. In this multiple case study, four schools were selected and

Mathematics teachers, ICT committee members and a member of the support staff at the Harry Gwala Centre were interviewed. In addition, focus group discussions were conducted with Mathematics learners. It was the main research question "***What is the viability of teaching and learning Mathematics in a paperless classroom*?"** for this study that dictated which the methodological approach should be followed; in this situation a qualitative study (Strauss & Corbin, 2008). Additionally, the qualitative research method was appropriate as it provided me with the opportunity to interrogate this change at the selected sites to establish the effects that this change had on day-to-day practices, which is the teaching and learning of Mathematics in a paperless context (Barbour, 2014). A qualitative study can clarify situations as it provides comprehensive information pertaining to the meaning that participants ascribed to their experiences regarding the teaching and learning of Mathematics in a paperless environment. This gave me the "… *opportunity to connect with them on a human level*" (Strauss & Corbin, 2008, p. 13). Furthermore:

> *… committed qualitative researchers lean toward qualitative work because they are drawn to the fluid, evolving, and dynamic nature of this approach in contrast to the more rigid and structured format of quantitative methods. Qualitative researchers enjoy serendipity and discovery. Statistics may be interesting, but it is the endless possibilities to learn more about people that qualitative researchers resonate to* (Strauss & Corbin, 2008, p. 13).

It is important for a researcher to be able to interact with participants as they are human beings with experiences and emotions and this interaction goes further than just quantifying responses, consequently, to present a portrayal of their worlds. Because it was important to elicit information from the participants regarding the viability of teaching and learning Mathematics in a paperless context, their words enabled me to gain deeper insight and comprehension of their emotions and experiences (Maykut & Morehouse, 1994).

In addition, qualitative research encompasses the documentation of actual occurrences, transcriptions of interviews, observation of behaviour and the examination of visual images (Creswell, 2014; Neuman, 2014; Denzin & Lincoln, 2008; Strauss & Corbin, 2008). Qualitative researchers rely on interpretative critical social science, where experience and interpretation are emphasised. Furthermore, qualitative research occurs in natural settings where the researcher "… *views social phenomena holistically*". Multiple methods are used for data collection, such as interviews, focus group discussions, observations, document analysis as well as audiovisual and video information, with the focus being on the context; essentially the research is interpretative (Marshall & Rossman, 2016, p. 3).

This study investigated the viability of teaching and learning Mathematics in a paperless classroom. To do this it was necessary to examine the challenges that teachers and learners encountered with the use of ICTs. The use of the qualitative method was suitable to elicit the rich, thick data to answer the research questions pertaining to the viability of teaching and learning Mathematics in a paperless context (Neuman, 2014). Creswell (2014) claimed that qualitative research is an inductive method used to explore and comprehend the meanings that participants or groups assigned to either a human or social problem. Since it was important to understand the attitudes, emotions, behaviour, knowledge and competence of both teachers and learners regarding the use of ICTs in the teaching and learning of Mathematics in a paperless classroom, it was appropriate that a qualitative study be conducted.

Researchers using qualitative methods attempt to understand the participants' innermost experiences as well as to establish how meanings are arrived at (Strauss & Corbin, 2008). This is precisely what this study attempted to do. I proceeded to experience the participants' domain from their perspective and attempted to uncover information that would add to empirical knowledge (Strauss & Corbin, 2008). The research design took the form of multiple case studies and is discussed next (Yin, 2012).

The Research Design

A multiple case study design located within the qualitative method was necessary to conduct this study. Three specific data collection methods were identified; in-depth semi-structured face-to-face interviews, focus group discussions, and classroom observations. These will be discussed in detail later in this chapter. My goal in using a multiple case study design provided me with the means to comprehend phenomena in their natural settings, in this situation Mathematics teachers and learners in paperless schools (Zach, 2006). For the purpose of this study, case studies provided a richer and more graphic portrayal of the phenomena being investigated (Marshall & Rossman, 1999). According to Patton (1990), case studies are predominantly used when researchers need to acquire a thorough comprehension of a minimal number of entities (Mathematics teachers and Mathematics learners), challenges (teaching in a paperless environment) as well as circumstances (the cases of paperless schools). Furthermore, "… *the validity, meaningfulness, and insights generated from qualitative inquiry have more to*

do with the information-richness of the cases selected and the observational/analytical capabilities of the researcher than with sample size" (Patton, 1990, p. 185).

Therefore, to elicit the requisite information, it was necessary for me to engage with Mathematics teachers and learners and observe whether paperless classrooms are viable or not. The role of the qualitative researcher is to collect the main data and therefore, to identify the biases and assumptions at the beginning of the study. My views concerning the viability of teaching and learning Mathematics in a paperless classroom, have been influenced by my experiences as a former Mathematics secondary school teacher. Having the knowledge and experience enabled me to investigate with an open-mind and negate whatever biases or assumptions I might have had regarding the topic. A description of case study research is presented next.

Case Study Research

A case study may be described as an in-depth investigation into a specific context, which is suitable to scrutinise a circumstance to gain rich insight into the identified issue (Yin 2014; Rule & John, 2011). Additionally, a case study allows the researcher to interact closely with the participants as well as to form associations with them (Rule & John, 2011). Valuable information pertaining to the phenomena under investigation is obtained from a case study. For the purpose of this study, multiple cases (paperless schools) were identified. In a multiple case study more than one case is involved and each case should have a specific purpose, should follow replication and the researcher should be fastidious in the choice of each case (Patton, 2014; Neuman, 2014; Yin, 2012; Stake, 1995). Each case should be regarded as an interaction with the cases that will produce similar results known as "*single literal replication*". The following skills are recommended by Yin (1994, p. 56):

> *... ask good questions - interpret answers - be good listeners - not be trapped by his/her ideologies or preconceptions - be adaptive and flexible - have a good understanding of issues being studied - be unbiased by preconceived notions - be sensitive and responsive.*

The benefits of using multiple case studies for examining and comprehending change, are namely; the viability of teaching and learning Mathematics, while using ICTs in a paperless context. Furthermore, it is significant as the description, documentation and interpretation of experiences as they occur in real-life situations may establish the aspects that underpin the use of ICTs in the teaching and learning of Mathematics in a paperless context. In addition, case

studies could contribute towards illuminating other similar studies that may have been conducted, however, no such studies on the viability of teaching and learning in a paperless environment have been found to date. By focusing on a few cases, the researcher investigates in-depth specific phenomena relevant to each case (paperless schools), by obtaining rich, thick data that may be described as intensive (Rule & John, 2011). Yin (2012, p. 10) stated "… *good case studies benefit from having multiple sources of evidence*". Case studies benefit from using a variety of data collection methods, such as direct observations, interviews, archival records, documents, participant-observation and physical artefacts. However, for this study, data were collected using in-depth semi-structured face-to-face interviews, focus group discussions as well as classroom observations of Mathematics lessons (Yin, 2012; Simons, 2009).

In a qualitative case study, the various viewpoints of participants are valued. Observations, as well as the phenomena being studied, take place where the actual phenomena are found, which are the Mathematics classrooms (Simons, 2009). The reason for conducting case study research is that it assists the researcher "… *to understand a real-world case*" (Yin, 2014, p. 16) as well as providing an invaluable understanding of specific conditions, occurrences, societies, classrooms and individuals (Rule & John, 2011).

Simons (2009) pointed out that there are additional benefits to conducting case studies. It offers the researcher the opportunity to investigate opposing perspectives and to elucidate the reasons for specific occurrences. The flexibility of a case study is an added benefit because there are no time limits nor are there any methodological constraints. Simons (2009, p. 23) asserted that this is a strength since "… *it can be conducted in a few days, months or several years and be written up in different forms and lengths appropriate to the timescale*".

To write up a good case study, it is necessary to use: coherent language, vignettes, cameos, direct observation of occurrences and a description of the settings, that permit the reader to indirectly encounter what has been described and to make use of their implicit knowledge to comprehend its implications. Paperless schools were introduced by the Gauteng MEC in 2015, however, to date, there has been no research undertaken on the viability of teaching and learning in a paperless context, neither locally nor internationally. Consequently, it was imperative to establish the viability of teaching and learning Mathematics using ICTs in a paperless classroom. Cognisance was taken of Yin's (1994) above-mentioned good advice,

when in-depth semi-structured interviews and focus group discussions were conducted with participants. To conduct the multiple case studies, appropriate research sites were identified, and permission was gained from the GDE and principals of the selected sites, prior to data collection.

Research Sites

A site refers to "… *the context in which events or activities occur and a socially defined territory with shifting boundaries"* (Neuman, 2000, p. 352). In the selection of a case, Miles and Huberman (1994, p. 27) stated that it should "… *set boundaries: define aspects of your case(s) that you can study within limits of your time and means, that connect directly to your research questions, and that probably will include examples of what you want to study*". Therefore, three sites chosen for this study were from a list of the seven paperless schools provided by the Ekurhuleni North District office of the Gauteng DoE. Because this was a multiple case study, three public schools; one from Ekurhuleni North, one from Ekurhuleni South and one from Ekurhuleni East were selected. In addition, one private school under the auspices of the GDE, although not identified as a paperless school, was selected as a research site because they were using tablets and were working towards being a paperless school. I decided that it would be insightful to include this school as I believed that the information obtained could be relevant to this study.

Gaining Access to Sites

To conduct research at Gauteng schools, it was imperative to seek permission from the Gauteng DoE. This required completing a form providing details of the study and the schools which I identified as research sites. The approval letter provided by the GDE, together with a letter requesting permission to conduct this study, was presented to the principals of the selected schools. The principals then introduced me to the heads of the Mathematics Department (HoDs) at each of their schools. A letter detailing the context of my study, as well as the consent letters, were distributed to the respective teachers by the Mathematics HoDs. Mathematics learners, who were minors at the time of conducting the study, and who agreed to participate, were given letters detailing the context and purpose of the study, to obtain parental consent. Additionally, assent forms were signed by selected Mathematics learners who had agreed to take part in the study.

When I initially requested permission from the GDE to conduct research, I listed five GDE schools that were identified as paperless schools, due to convenience sampling that was used to select the case studies. Contact was made using emails to the principals at all five schools to meet and discuss my research. Three of the five principals responded promptly, appointments were scheduled with them and the data collection commenced immediately. However, no responses were received from the other two school principals, despite the numerous attempts to contact them.

After having collected data from the four schools that I had identified, when no further new data were obtained, it was evident that I had reached data saturation levels. Charmaz (2000 in Creswell, 2014, p. 189) stated that "… *you stop collecting data when the categories (or themes) are saturated: when gathering fresh data no longer sparks new insights or reveals new properties*". Consequently, I deemed it unnecessary to make further contact with the remaining two schools and therefore, excluded them from my list of research sites. Each research site where the study was conducted, is discussed next. To maintain confidentiality and anonymity of the participating schools, pseudonyms were used rather than the school names.

Ilungelo Secondary School

On my initial contact with the above-mentioned school, I was informed by the secretary that the Deputy Principal would be the correct person to liaise with as he was the person responsible for "driving" the ICT initiatives at this school. Consequently, an appointment was arranged with the Deputy Principal to explain the purpose of my study as well as the reason for selecting this school as one of the research sites. On my arrival at the school, I was directed to the reception area, which was relatively small with limited seating space to accommodate visitors. The reception area was over-crowded despite there being only five parents, with the result that I had to wait at the door. However, what was noteworthy is the attention to security. Access to the remainder of the school was gained through a locked security gate that required fingerprint access from staff members or entry could be controlled from the office by the receptionist. I eventually approached the receptionist at her window and requested to meet with the Deputy Principal with whom I had the appointment.

At this meeting, I explained my rationale for conducting this study and asked the Deputy Principal if he would distribute the assent letters for the focus group discussions, consent letters for learners' parents as well as consent letters to the Mathematics teachers. Mr Mbatha, the Deputy Principal, agreed to distribute these letters to the participants, however, on attempting to arrange for the collection of these consent and assent forms on numerous occasions from him, it became very frustrating as he was continuously unavailable, and time was running out. I, subsequently, decided to visit the school for a second time to ascertain what the problem was. On my second visit to the school, the Deputy Principal referred me to the Mathematics HoD, who kindly introduced me to the Mathematics teachers. I obtained the contact details of each of the Mathematics teachers, which I then used to schedule appointments for the interviews, classroom observations and focus group discussions.

Prior to my first appointment, I had the opportunity to view the school and its surroundings. This school is an historically White ex-Model C school that boasts extensive well-maintained gardens. The classrooms were fairly large, accommodated the learners comfortably and the teacher was able to walk around the classroom with ease to assist the learners. Regarding technology, I was informed that all the Mathematics classrooms had smartboards except for one, and Wi-Fi connectivity was readily available throughout the school. Each of the teachers had a laptop and every learner should have had a tablet, however, some learners did not have their tablets, due to several reasons, which will be discussed under challenges in Chapter Six. In addition, although this school was identified as a paperless school, the accuracy, the suitability as well as the veracity of such an identification, will be discussed in Chapter Five.

Iziphethu Secondary School

The atmosphere at Iziphethu Secondary School was very warm and inviting. The Principal welcomed me and regarded the selection of his school to participate in this study as an honour. While waiting at the reception area, I was warmly greeted by members of staff who happened to walk in, either to the reception office or to the staff room. On each visit, the Principal made a point of welcoming me and invited me to sit in his office while I waited for the Mathematics HoD and teachers.

The administration block housed the offices of the Principal, the Deputy Principal as well as the administrative staff and receptionist in one office. To the left of the reception area was a short corridor that led to the kitchen and the staff room, and to the right was another short corridor that led to the offices of the Principal and Deputy Principal. On the walls of the reception area were life-size pictures of the President of South Africa, the Minister of Basic Education and other individuals involved in education. On exiting the reception area, there was a quadrangle surrounded by classrooms. During the break, learners gathered here, and this could perhaps be because of the availability of Wi-Fi connectivity as well as individuals selling food and beverages.

The Mathematics HoD arranged interviews with the Mathematics teachers. These were successfully conducted. However, a problem arose when the HoD approached the Mathematics teachers to arrange the classroom observations. I arrived at the site to conduct the classroom observations only to be informed that a colleague had passed away, and teachers were not in the right frame of mind to be observed. I had no alternative but to leave. Before leaving, I requested the HoD to arrange an alternate date to conduct the observations, which she did. However, on arrival at the school for the second time, I was asked to wait in the reception area for the HoD. I waited there for a considerable length of time. The Principal, who passed me on numerous occasions, was concerned that I had not been attended to. He took it upon himself to attempt to contact the HoD but was unsuccessful. He subsequently, summoned the Mathematics teachers concerned to his office and requested that I communicate directly with each of them.

Considering that this school is located forty-five kilometres from my home, and I had to make two return trips, which was costly both financially and timewise, I therefore, requested one of the teachers, Mr Nkosi to make the necessary arrangements for the classroom observations and focus group discussions with the Mathematics learners. Mr Nkosi was most efficient in arranging these appointments, which proceeded very smoothly, thereafter.

At the end of each classroom observation, Mr Nkosi escorted me to the next classroom where the subsequent observation was to be conducted. All Mathematics classrooms at this research site were small and over-crowded, which prevented the teacher from walking around to assist learners. The size of the classroom also inhibited the learners' movement. Since the classrooms

were not large enough to accommodate the number of learners' desks, there was little or no room for a teacher's table. Consequently, teachers substituted a learner's desk as a teacher's table on which they placed their laptops. All classrooms had a minimum of one smartboard, however, those classrooms that had two smartboards, often the second one was not in working order. One of the classrooms had a traditional whiteboard propped against the smartboard that was not working, which had evidence of a Mathematics lesson that had previously been taught. At this site, each of the Mathematics teachers had a laptop and learners had been given tablets.

The focus group discussions with Mathematics learners, as arranged by Mr Nkosi, were successful. He had assembled each group of learners in a vacant office so that the focus group discussions could be conducted without any disturbances. Since this school was identified as paperless, evidence relating to whether Mathematics was being taught in a paperless context or not, is presented in Chapter Five.

Isilomo Secondary School

My initial visit to this school was to meet the Principal to inform her about the purpose of this study and the reason for selecting the school as a research site. On my arrival for the first appointment with the Principal, I was greeted by a very pleasant security guard who directed me to the visitors parking and escorted me to the reception area. The reception area could be described as a large passageway that led to the staffroom on the right, the Principal's office on the left and directly opposite the entrance to the reception, was a door leading to the rest of the school. Before exiting the reception area, to the right of the door was a life-size poster that informs visitors that this is a paperless school. In the reception area, there were life-size photographs of the President of South Africa and other members of the DoE.

My interaction with the Principal of this school was very amiable and she indicated that she was pleased to accommodate me to conduct my study. It was on this visit that the Principal introduced me to the Mathematics HoD and indicated that from then on, all communication would be between the HoD and myself. I subsequently handed the relevant research documents to the HoD for distribution to the research participants. At this meeting, the HoD and I agreed to communicate using WhatsApp for any further communication. What contributed to the success of my data collection at this school was the prompt response from the HoD, who had

scheduled appointments for the teacher interviews within a week of my first visit to the school. The schedule which indicated the date, the name of the teacher, the time of the interview as well as the venue where the interview would take place, was forwarded to me well in advance. On arrival for the interviews, I was met by the HoD in the reception area, who escorted me to her office as the first interview was scheduled with her.

On exiting the reception area, the HoD and I followed a walkway to a double-storey block, proceeded up the stairs to the first floor to her office, where the in-depth semi-structured face-to-face interview was conducted. She shared this office with two other HoDs. After the interview with the HoD, the next appointment was with a Mathematics teacher, who chose to be interviewed in the HoD's office. After the interview with the second participant, the HoD arrived to escort me to the next appointment. To reach the third participant's office, it was necessary to cross a quadrangle that was surrounded by classrooms and offices. The surrounding areas of the schoolyard were relatively clean. On one side of the quadrangle, the on-site Harry Gwala Support Centre was situated.

The Mathematics classrooms, where the classroom observations were conducted, were large enough to accommodate the learners. The layout of all Mathematics classrooms visited, were arranged in a traditional manner, where all learners faced the smartboard. The exception was the HoD's classroom, where learners sat in groups at hexagon-shaped tables. All Mathematics classrooms had one smartboard, except for one that had two smartboards and one that had a traditional chalkboard. Only one of the Mathematics classrooms was appropriately designed for the use of technology; for example, there were blinds that could be used to control the amount of light as required for the use of technology in the classroom. It is important to point out that the appointments for the interviews, classroom observations and focus group discussions were efficiently managed by this HoD, making it possible to complete the collection of the data within the stipulated time and without any difficulties.

Intaba Secondary School

This is an affluent private boarding school situated in Northern Gauteng. Being a private school, I had to seek permission from the Principal of the school to conduct my studies as the permission obtained from the GDE was not applicable to this school. I contacted the school

telephonically on numerous occasions to arrange an appointment with the Principal, but this proved to be rather difficult for various reasons. I finally managed to arrange an appointment with the Principal, with the assistance of Ms Ahmed, who at that time was a member of the ICT school committee. On meeting the Principal, I explained the purpose of my visit which was to inform him about the purpose of my study as well as the reason for choosing the school. The Principal was most accommodating and went out of his way to assist me. He initially had a meeting with the Mathematics teachers to inform them that I would be contacting them to schedule appointments to conduct interviews with them, classroom observations of Mathematics lessons and focus group discussions with Mathematics learners. It was at this meeting that he distributed the letters to the Mathematics teachers with the information pertaining to my study, as well as the consent and assent forms. He then sent me an email with their contact details, which I used to contact the HoD, who arranged the interviews to be conducted with each teacher. Within an hour of my contacting the HoD, he had provided me with the schedule of the details for the interviews.

Considering that the Principal himself was studying towards his Master's degree, he identified with some of the problems that Master's and Doctoral students experience with the collection of data. Consequently, he requested Ms Ahmed to assist with the scheduling of the focus group discussions with the Mathematics learners as he did not want to jeopardise my data collection. I requested Ms Ahmed to arrange focus group discussions with a minimum of seven learners per grade, from Grades 9 to 11. However, she experienced problems with learners not having returned the consent and assent forms timeously. Therefore, she was only able to arrange one focus group discussion, which included learners from the different grades.

To gain access to the school, it was necessary to pass through two security entrances. The first security check is at the entrance to the school premises where the sporting facilities are situated. Driving past this area, a second security check allows access to the school buildings. This was a very impressive drive from one security checkpoint to the next. The architecture of the school is modern and striking. A special feature is the stairwell, which was designed to resemble windows, however, there are no window panes. The well laid out gardens are an added feature that signifies affluence. Evidence of groundsmen actively working in the school grounds contributed to the clean and neat appearance.

The school comprises a primary and secondary school on the same grounds, however, the primary school will be moving to their own premises, which is adjacent to the secondary school. The classrooms of the secondary school are large and easily accommodate thirty learners. Because the classrooms are large, teachers can arrange the desks in a manner that suited their teaching styles. The only technology visible in the classrooms was a data projector fixed to the ceiling and the teacher's laptop. In every classroom was a standard whiteboard and there was no evidence of a smartboard in any of the Mathematics classrooms. Each learner had their textbooks on their tablet, and each teacher had their laptop or tablet, which they used for teaching and learning. The discipline at this school was exceptional. Learners adhered to the change of periods without being reminded by a siren, which is used by public schools to indicate the change of periods. Compared to the selected government schools included in this study, the noise levels at this private school, were minimal. The socio-economic status of the area is evident as the school is surrounded by sizeable properties, a sign of affluence surrounding the school. Having described the research sites, attention is paid to the research population, sample and participants.

Research Strategies, Selection of Participants and Research Participants

A population includes all individuals that satisfy certain criteria to be included in the study (De Vos, Strydom, Fouché, & Delport, 2006). For this study, the research population was Mathematics teachers and learners from selected GDE paperless schools, as well as from a private school, which was in the process of becoming a paperless school.

Stake (2000) maintained that the selection of participants is key for a case study. Considering that this is a multiple case study, the sampling technique was distinctive because "… *each setting has a few properties it shares with many others, some properties it shares with some others, and some properties it shares with no others"* (Miles & Huberman, 1994, p. 29). The commonality amongst Mathematics teachers in this study was that they integrated ICTs in teaching and learning, however, how they used ICTs differed profoundly in a "so-called" paperless environment.

Flick (2006) stated that participants for a study should be selected according to the value that they can bring to the study as the objective in a qualitative study is credibility and not

representativeness or the need to generalise. Therefore, the method that was used was dictated by the phenomenon that was being studied as well as who the participants for the study should be. Consequently, convenience and purposive sampling methods were used to select the participants. In a qualitative study, Stake (2000, p. 446) said "… *we draw a purposive sample, building in variety and acknowledging opportunities for intensive study*". According to Merriam (2009), purposive sampling is used to identify cases that provide the most information about the subject being studied. Therefore, it was necessary that the participants satisfied the criteria of being Mathematics teachers and learners from paperless schools, as well as being easily accessible and within reasonable proximity to my residence.

There are three contexts when purposive sampling is suitable, initially, the researcher chooses specific cases to provide good information. Next, purposive sampling may be used to identify members of a specialised population (Neuman, 2014; Neuman, 2000), which requires a judgement based on available information about a specific population, characteristics or circumstances. In this study, the participants were teachers and learners who used ICTs in their teaching and learning is schools identified as paperless. Lastly, purposive sampling is used when a researcher intends to identify specific kinds of cases for a comprehensive study (Silverman, 2011). This method of sampling was most appropriate for this study as it focused on the viability of the teaching and learning of Mathematics using ICTs in a paperless context and consequently, required schools that were categorised as paperless (Denzin & Lincoln, 1994).

Initially, the decision was to interview Mathematics teachers, and conduct focus group discussions with Mathematics learners, followed by observing how Mathematics lessons were taught solely with the use of ICTs. However, during the data collection process, the opportunity arose for additional interviews to be conducted with two ICT committee members at two different research sites, as well as a member of the Harry Gwala Support Centre. This is referred to as snowball sampling where the researcher obtains additional participants from referrals (Neuman, 2000). Technology support is extremely important when using technology for teaching and learning, and more so in a school identified as paperless. It was for this reason that I chose to include these staff members as research participants. In addition, a deputy principal at a selected site, volunteered to be interviewed as he claimed to have been involved

with paperless schools from its inception, and believed that he had valuable knowledge to impart on the topic.

Qualitative researchers choose samples, which are a limited collection of cases or an activity that "… *illuminates social life*" (Neuman, 2000, p. 196). The key purpose of sampling is "… *to collect specific cases, events or actions that can clarify and deepen understanding*" (Neuman, 2000, p. 196). Consequently, the number of participants chosen in each case was dependent upon the number of Mathematics teachers at each research site that agreed to take part in this study. In addition, two or three focus group discussions of seven to ten learners per group was conducted per site. The exception was the private school where only one focus group discussion was conducted due to the problems experienced by Ms Ahmed regarding the return of both consent and assent forms by learners. It was not always possible for all the focus groups to have the minimum number of learners as many did not return the consent forms from their parents. In addition, I chose not to include Grade 12 learners in the focus group discussions because I did not want to disrupt their teaching and learning time. After selection of the sample, data collection followed. The different data collection methods used in this study are presented below.

Data Collection Methods

For this study, several data collection methods were used; these were semi-structured in-depth face-to-face interviews, focus group discussions and classroom observations. The first data collection method was semi-structured in-depth face-to-face interviews with Mathematics teachers as well as one deputy principal, two members of the ICT committee and one staff member from the Harry Gwala Support Centre. An interview schedule was used to guide the interview process (see Appendix C).

Semi-Structured In-Depth Face-to-Face Interviews

The primary method of data collection for this study was semi-structured, in-depth face-to-face interviews as "… *researchers use semi-structured interviews in order to gain a detailed picture of a participant's beliefs about, or perceptions or accounts of, a particular topic*" (De Vos et al., 2005, p. 297). This method allowed the researcher to revisit issues, topics or aspects that

required further clarity thus providing greater insight and understanding into the viability of teaching and learning Mathematics in a paperless context. Interviews are also a valuable source of evidence and a significant source of case study information (Patton, 2002; Neuman, 2000; Yin, 1994). In-depth semi-structured face-to-face interviews provide participants the opportunity to describe and elucidate their experiences, which may offer significant understandings about the topic being investigated. In this case; it was the viability of teaching and learning Mathematics in a paperless context. However, there may be some challenges that could be experienced with interviewing such as bias, poor recall and inaccurate verbalisation.

With interviews, it is the interviewee that in essence controls the flow of the interview. The interviewer uses the responses of the interviewee to further probe and extract elaborations and clarity (Seidman, 2006). To establish a deeper understanding, in-depth semi-structured face-to-face interviews assisted in eliciting the required views, attitudes and opinions of Mathematics teachers, who use ICTs in teaching and learning (Creswell, 2014; Seidman, 2006). In a qualitative study, it is the intention of the researcher to comprehend the connotations that teachers in education ascribe to their experiences, thus interviews were essential and adequate to elicit the required information (Seidman, 2006).

Open-ended questions were used as they allowed the participants to share their perceptions, ideas and experiences regarding the phenomenon that was studied (Creswell, 2002), which was teaching and learning Mathematics in a paperless context. The interviews were guided by "… *a set of pre-determined questions on an interview schedule*" as recommended by De Vos et al. (2005, p. 297). In addition, an interview may also be described as "… *a conversation with a purpose*" (De Vos et al., 2005, p. 292). It is essential that the interviewer is interested in what the participant has to share. This encourages the participant to speak without any inhibitions, thus allowing the interviewer to understand their daily experiences (Marshall & Rossman, 2006).

According to Simons (2009), despite interviewing being labour intensive, there are four key reasons for conducting in-depth face-to-face interviews. Initially, it is to record the participants' views and attitudes on the subject being investigated. Thereafter, interviewing encourages both the researcher and participant to recognise and consider concerns. A third reason is that interviews are adaptable because the researcher can follow an alternative path of questioning

to elicit multifaceted information, thus participating in discourse with the interviewee. Finally, in-depth face-to-face interviews provide the possibility to unearth emotions and occurrences that may not be visible and provide information that may not have been observed. It is necessary for an interviewer to ensure a good relationship with the participants to obtain rich, thick data and create an environment where they are relaxed and willing to articulate their opinions and experiences.

It is also necessary for participants to be comfortable in the company of the researcher and their surroundings before sharing their experiences, therefore, interviews should be conducted in surroundings that encourage free speech (Silverman, 2005). Consequently, teachers were permitted to choose the location where the in-depth face-to-face interviews were conducted. The majority of the teachers opted to be interviewed in their classrooms, while others chose an alternate venue at their school that was conducive to conducting the interview. Participants from management or those providing support regarding ICT-use at the respective schools, chose to be interviewed in their offices. Each interview was audio recorded with the permission of the participants; this provided the necessary evidence to maintain an audit trail. The interviews were transcribed verbatim immediately after it was completed. These interview transcripts were emailed to the respective participants for comments. A few of them responded that the interview transcript was a true reflection of what they had articulated, whereas others chose not to respond. Soon thereafter, the initial analysis of open coding of the raw data began. Labels were assigned to the raw data for further analysis at a later date; this is referred to as axial coding. After completion of the interviews with the Mathematics teachers and other staff members, focus group discussions were held with the learners who use ICTs to learn Mathematics. The intention was to collect data of their opinions and experiences regarding the teaching and learning of Mathematics in a paperless environment.

Focus Group Discussions

A focus group discussion is meticulously designed to acquire opinions on a specific phenomenon of interest, in an open-minded and reassuring setting as Neuman (2014, p. 472) points out "… *the natural settings allow people to express opinions/ideas freely"*. Consequently, all the focus group discussions at three of the sites were conducted in Mathematics classrooms except for Iziphethu Secondary School where all the focus group

discussions were conducted in the Deputy Principal's office. The Principal at this school did not want anyone or anything to disturb the focus group discussions. Deciding on the minimum number of participants to include in a focus group discussion, is difficult. McNeill and Chapman (2005) suggested that the group should consist of eight to twelve participants while Neuman (2014) suggested that the number of participants in a focus group should comprise six to twelve participants and be moderately homogenous.

For this study, eight focus group discussions were held at the selected sites. Despite trying to obtain ten participants per focus group to remain within the range of participants as advised by both McNeill and Chapman (2005) as well as Neuman (2014), five of these focus groups included six learners each, one group had eight learners while the remaining two each had seven learners. The reason for the reduced number of participants per focus group was the problem with the timeous collection of both consent and assent forms from learners. Bearing in mind certain constraints, such as learners being interviewed after school hours so as not to disturb their learning, as well as prior arrangements having been made with parents regarding the date, time and venue where the focus group discussion would take place, I chose to continue with the focus group discussion as the minimum number of participants in some of the groups satisfied the recommendation by Neuman (2014).

A focus group comprises many participants and "… i*ndividuals in the group cue or prompt each other in ways that an interviewer – even an experienced and well-prepared one - is not able to do*" (Remler & Van Ryzin, 2011, p. 70). These participants are encouraged to converse with one another instead of responding to the facilitator or researcher, allowing them to express their thoughts and experiences (McNeill & Chapman, 2005). Unlike in-depth face-to-face interviews, in a focus group it is not necessary to ask individual participants questions, as they are encouraged by researchers to talk and interrogate each other as well as share narratives while interacting with each other about various perceptions, opinions and experiences that they concur with or oppose (Barbour & Kitzinger, 1999). This difference between in-depth face-to-face interviews and focus group discussions is important, making this method of data collection from learners the most appropriate method; the interaction between participants could lead to revealing important information, which would add to the data. Inevitably, participants will debate certain matters thus enabling the interviewer to establish their opinions, experiences and

attitudes towards learning Mathematics in a paperless classroom, which is precisely what transpired in these focus group discussions.

Focus group discussions have several benefits; they are cost-effective and not intimidating to individuals (Simons, 2009). Since the participants in the focus group discussions were Mathematics learners, they needed to be among their peers to make them feel comfortable and not intimidated. Additionally, Neuman (2014, p. 472) stated that participants in a focus group discussion "… *may query one another and explain their answers to one another*". This is precisely how the focus group discussions proceeded, as participants at all the sites either added to what was being said or questioned members when they disagreed. There appeared to be considerable excitement among the learners in some of the focus groups, which contributed to an intense debate concerning specific comments made by certain participants. However, in three groups the discussions were not as animated and informative. What was also interesting was to see how the different participants argued with one another, agreeing on certain issues while debating others with fervour. Despite the numerous advantages that focus group discussions offer, the researcher must take cognisance of the disadvantages as well, to ensure that the information obtained from the focus group discussions are authentic and valuable.

When compared with individual interviews, focus group discussions are more difficult to control as the interviewer has to keep a close watch on what occurs within the group. Various group dynamics, such as conflict and power struggles may inhibit discussion (Marshall & Rossman, 2016). Individuals who lack confidence may feel threatened by more self-confident individuals. There is a possibility in focus group discussions for certain individuals to dominate the discussion, and so exclude others from contributing. McNeill and Chapman (2005, p. 65) concur:

> *… strong personalities may dominate discussion, influence less vocal members of the group and silence dissent. On the other hand, some researchers note that ethnic minority groups and children are more likely to feel supported and therefore will express themselves when they are surrounded by others like themselves.*

It is, therefore, imperative that the researcher ensures that all members of the group are involved in the discussion and less vocal members of the group should be encouraged to participate. This was a problem that I encountered with two of the eight focus group discussions at two of the research sites. There were members in these groups, who attempted to dominate the

conversation but in a very subtle and affable manner, I managed to include other speakers by thanking the participant who was dominating the discussion for their contribution and asking whether anybody else had other ideas regarding what was being discussed.

In addition, Marshall and Rossman (2016) added that often in focus group discussions, the participants tend to focus on irrelevant issues, and as a consequence, valuable time is lost. This is exactly what transpired with two of the focus group discussions at different sites. Some of the participants from one of the focus groups at Iziphethu Secondary School believed that they were more competent regarding technology skills when compared to the other teachers at the school. As a result, they concentrated more on talking about how "good" they were instead of focusing on the topic at hand. The second group focused on the different types of devices that learners had and the inaccessibility to Wi-Fi. It was necessary for me to re-direct the conversation when this occurred.

For the researcher to have a view of the entire group and for the participants to be able to see and hear each other, the group was seated in a semi-circle. This allowed me to maintain eye contact with the participants and pose specific questions to encourage their participation. I also ensured that non-verbal cues were not used to obtain desired responses. It was important to remain impartial by not displaying any body language that could be interpreted incorrectly, whilst maintaining eye contact at all times with the speaker. At no point should the researcher get involved with the conversation but should only concentrate on asking open-ended questions. The conversation ensued without suppressing the opinions that were offered.

To make the process of a focus group discussion easy to manage, I had to initiate the discussion in the group but abstain from participating. The duration of the focus group discussion was limited to an hour. However, one focus group discussion lasted one hour and twenty minutes because the participants were captivated by the topic and wanted to continue. Although it is suggested that focus group discussions should be limited to an hour, this group had much to offer, participants were passionate about sharing their thoughts and experiences, consequently, I chose to continue a little longer with the data collection. However, the onus was on me to conclude the discussion after an additional twenty minutes and remind the learners that their transport was waiting, and their parents had been informed that the duration of the focus group discussion would be an hour.

On arrival of the focus group participants, I welcomed them, introduced myself and thanked them for their willingness to participate in this study. In order to build a rapport with the participants in the group, we had polite conversations before the beginning of the focus group discussion. Neuman (2014, p. 471) advised that "… *providing very clear instructions and carefully selecting participants for the focus groups can greatly shape the outcome*" of a study. Therefore, each learner was given a number and instructed how to use the number when participating in the discussion. Thereafter, I explained the ground rules and they were given the opportunity to ask for clarification where necessary. They were informed that the ground rules had to be adhered to throughout the focus group discussions. It was incumbent upon me to ensure that the participants felt comfortable to voice their opinions, whether positive or not, since this was not an interrogation, but a sharing of experiences and opinions. Learners were assured that I would keep the information collected from the focus group discussions confidential and secure. Learners were informed that an audio recorder would be used to record the focus group discussion. The audio recorder was strategically placed on the table to capture what learners had to say during the focus group discussion.

At the end of each focus group discussion, participants were thanked once again for their willingness to share their opinions and experiences openly and honestly. I explained what would be done with the data that was collected and once again assured them of their confidentiality and anonymity, even though confidentiality at times may be compromised due to the number of participants involved in a focus group discussion (Patton, 2002). Once the focus group discussions were completed, they were transcribed, and the first step of the analysis procedure commenced. Classroom observations were conducted to corroborate some of the data collected from the in-depth face-to-face interviews with Mathematics teachers, and the focus group discussions with Mathematics learners.

Classroom Observations

> *Qualitative research sometimes involves direct observation of behavior. Rather than interview people, the researcher directly observes a setting or behavior and takes notes* (Remler & Van Ryzin, 2011, p. 71).

It was important that classroom observations be conducted with those Mathematics teachers, who participated in this study, to verify or add to the data collected during the individual in-depth face-to-face interviews. When conducting case study research, the investigator can draw

upon the senses, collect data from observations and what is heard by compiling field notes. These field notes contribute to the data collected (Yin, 2012). Observations allow the researcher to obtain a complete image of the location, which includes the 'setting', since these may not be identifiable in the interviews. Recording occurrences in a classroom provide a source for subsequent enquiry by using observations to uncover those aspects that participants may have omitted to mention (Neuman, 2014). Creswell (2014, p. 191) concurred; *"[A] researcher has a firsthand experience with the participant … unusual aspects can be noticed during observation … [and it may be] useful in exploring topics that may be uncomfortable for participants to discuss*". In addition, observations may provide alternative means for the researcher to document the experiences of participants, who were unable to express their true emotions and experiences in interviews, which may have contributed to the authenticity of the study (Simons, 2009).

According to Neuman (2014), the researcher's presence in the classroom may be perceived as intrusive. At one of the selected sites, it was difficult to arrange for the classroom observations, perhaps because teachers in this instance perceived the observation of their lessons as an intrusion. As the focus of this study was on the viability of teaching Mathematics in a paperless classroom, observations had to be conducted to establish how Mathematics is taught in a paperless context as a paperless classroom is completely devoid of the use of pen and paper, as articulated by the Gauteng MEC. Once all the data were collected and transcribed, data analysis began.

Data Analysis Procedures

> *Data analysis means a search for patterns in data – recurrent behaviours, objects or a body of knowledge* (Neuman, 2000, p. 426).

Data were analysed using qualitative analysis techniques. The data collected during the interview process were transcribed, assigned labels and subsequently analysed (Neuman, 2014; Patton, 2002). Marshall and Rossman (2011, p. 164) cautioned that during the transcription of recorded data, the transcriber must pay particular attention to the insertion of commas, full stops or semicolons because this can shape or change the meaning of the data since human beings do not "*signal punctuation*" when they talk. Consequently, I chose to transcribe the data myself, taking cognisance of Marshall and Rossman's (2011) advice. Additionally, once the

teacher interviews were transcribed, the transcriptions were emailed to the participants for comments, this is known as member checking (Patton, 2002).

During the data analysis process, units of meaning are assigned to the data using codes or labels, which may be either descriptive or inferential. Portions of data are usually coded, these may vary in size, for example, individual words, phrases, sentences or paragraphs, which may be related or unrelated to a particular setting (Miles & Huberman, 1994).

According to Strauss and Corbin (2008, p. 16):

> *Qualitative analysis is many things, but it is not a process that can be rigidly codified. What it requires, above all, is an intuitive sense of what is going on in the data, trust in the self and the research process, and the ability to remain creative, flexible, and true to the data all at the same time. The most important is the desire to step beyond the known and enter into the world of participants, to see the world from their perspective and in doing so make discoveries that will contribute to the development of empirical knowledge.*

Consequently, they recommended that before the initial stage of coding the researcher should read through the transcript and engage with the participants' attitudes, experiences and emotions. The analysis was affected by initially preparing and organising the data by exploring the data for; emerging themes, representing, reporting, interpreting, inferring and authenticating the accuracy and credibility of the findings (Creswell, 2002; Neuman, 2000).

Figure 4.1 below illustrates the data analysis process that was followed for this study. Data 1 is the raw data collected from the interviews, focus group discussions and observations as well as my experiences as the researcher. Recorded data were represented by Data 2 and finally, the selected data, which has ultimately been processed into the final thesis, is represented by Data 3.

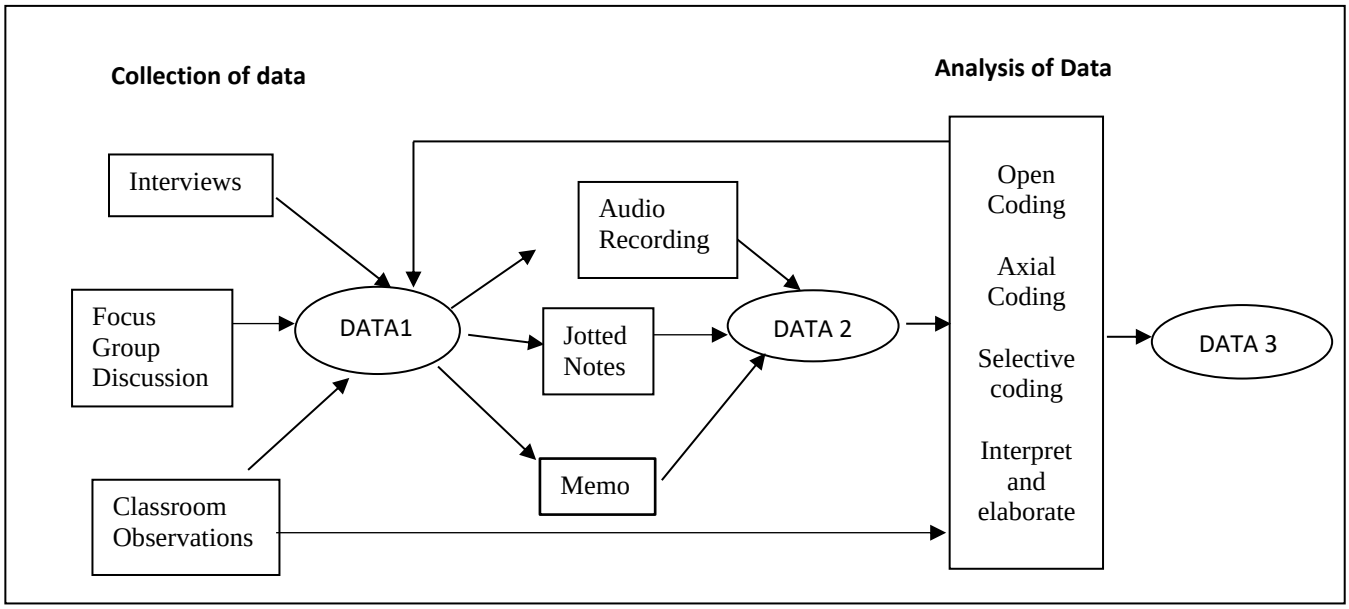

Figure 4.1 Data Analysis – Search Patterns in Data (Adapted from Neuman, 2000, p.426)

Data collected were analysed using the three stages of raw data analysis as recommended by Neuman (2007); open coding, axial coding and selective coding. Strauss and Corbin (2008, p. 198) stated that "… *open coding and axial coding go hand in hand. The distinctions made between the two types of coding are "artificial" and for explanatory purposes only, to indicate to readers that though we break data apart, and identify concepts to stand for the data, we also put it back together again by relating those concepts".* Despite the contention regarding open coding and axial coding, these two components of the analysis procedure are discussed separately.

Open Coding

> *Open coding is the part of analysis that pertains specifically to the naming and categorising of phenomenon through close examination of data. During open coding the data are broken down into discrete parts, closely examined, compared for similarities and differences, and questions are asked about the phenomena as reflected in the data* (De Vos et al., 2005, p.341).

Open coding, which is the first pass through the raw data, began with assigning labels to individual words, sentences and paragraphs as recommended by Miles and Huberman (1994). Thereafter, analytic notes that were made during the data collection process were consulted to establish whether the codes assigned were confirmed by these analytic notes. Subsequently,

the labelled data was organised into conceptual categories and themes as they emerged. Some of the themes that emerged at this stage were precisely what had been anticipated.

Axial Coding

The next step in the data analysis process is described as axial coding, which is the second pass through the already labelled data. During this stage of data analysis, the researcher focuses more on the preliminary coded themes instead of the data. Neuman (2014, p. 483) adds that "*… additional codes or new ideas may emerge during this pass, and you should note them, but your primary task is to review and examine the initial codes*".

Axial coding also encourages thought about how concepts are linked, therefore, this stage might include "*… grouping the codes according to conceptual categories that reflect commonalities among codes" (*Marshall & Rossman, 2011, p. 215). Therefore, the onus was upon me to identify associations between the categories and the emergent sub-categories. The identification of the above-mentioned associations required me to revisit the initial codes and to search for overlaps. I focused on the initial emergent themes in an attempt to organise them and identify reasons, results, circumstances, interactions and procedures to ascertain which were the major themes and which minor themes could be incorporated into the major themes. In addition, Neuman (2014, p. 484) adds that axial coding does not only encourage thought about associations among the concepts and the emergent themes but "*… it raises new questions*". As a result, the researcher may choose to leave out certain themes while other themes may be examined more in-depth. "*As you consolidate codes, you may find evidence in many places for core themes. The connection between a theme and data is strengthened by multiple instances of empirical evidence*" (Neuman, 2014, p. 484). This is the method that was used to identify the themes and subthemes for this study, which answered the main research question on the viability of teaching and learning Mathematics in a paperless environment. Subsequently, these themes were clustered for the final pass through the already clustered data.

Selective Coding

The final pass through the already categorised data is known as selective coding. where the researcher selected the most prominent themes, which answered the research questions

(Neuman, 2014). During the analysis of the raw data, the researcher kept the research questions in mind when assigning labels to the raw data, categorising and selecting themes. Selective coding involves scanning the data and the previous codes. At this stage of the analysis, I searched for instances that illustrated themes and consequently contrasts and comparisons were affected between the emergent themes. During the process of selective coding, I scrutinised the fieldnotes, searching for discrepancies, inclusions and differences. In a qualitative study, it is imperative that the researcher takes note of their biases and presumptions as this could influence the results (Maykut & Morehouse, 1994). To ensure that the interpretation of the data is not superficial, it is important to follow Neuman's (2000, p. 441) dictum with reference to "outcropping". This is a term borrowed from Geology, where the Geologist examines the bedrock beneath the surface. Likewise, the researcher delves beneath the surface reality of the collected data to establish profound meanings and interpretations.

Software Tools for the Analysis of Qualitative Data

According to Marshall and Rossman (2016, p. 227)

> *Computers can assist the analysis phase because they facilitate making and writing observational notes, editing, coding, storing, searching and retrieval, linking data, writing memos, analyzing content, displaying data, drawing and verifying conclusions, building theory, mapping graphics, and writing reports*.

This is precisely how I used the computer for this study. However, although there are many computer programmes to analyse qualitative data, one of which is AtlasTi, none was used for the analysis of the raw data. I felt I needed to be in charge of and personally engage with the analysis of the data. If computer software is used to analyse data, the researcher still needs to think about the meaning of the transcribed data and write memos because contemplating on the transcribed data is essential in qualitative data analysis (Strauss & Corbin, 2008).

As early as 1998, Barry identified various disadvantages of using Computer Assisted Qualitative Data Analysis Software (CAQDAS), which are confirmed by McLafferty (2006) and Kodish and Gittelsohn (2011). The first disadvantage is that researchers have to familiarise themselves with the CAQDAS tool. In addition, the transcripts may have to be converted into a format that is acceptable by the selected CAQDAS tool. These authors claim that this process is time-consuming. McLafferty (2006, p. 36) stated that if researchers are not cautious during the coding process, it may result in "over coding" of the collected data, thereby rendering the

process of classifying the data a difficult task as too many themes and categories may emerge which may not be relevant to the study. In addition:

> *… if codes and categories become fixed by the software, the data analysis process may be inhibited. Conceptualising data on the computer screen can be difficult, inhibiting visualisation and contextualization* (McLafferty, 2006, p. 36).

Kodish and Gittelsohn (2011, p. 54) mentioned that "… *better programs may be cost prohibitive*". They added that the use of CAQDAS may detach the researcher from the data being analysed. Furthermore, if the analysis of the data requires teamwork, the use of CAQDAS could be challenging when sharing files. Finally, they added "… *computer software can help with coding, but it cannot help ensure high-quality data or findings*" (Kodish & Gittelsohn, 2011, p. 4).

Bearing the above in mind, the rich, thick data collected for this study required me to think deeply about the interpretation and presentation of the findings, consequently, I chose not to use any of the CAQDAS tools available. Figure 4.2 below provides a summary of the research design as described above.

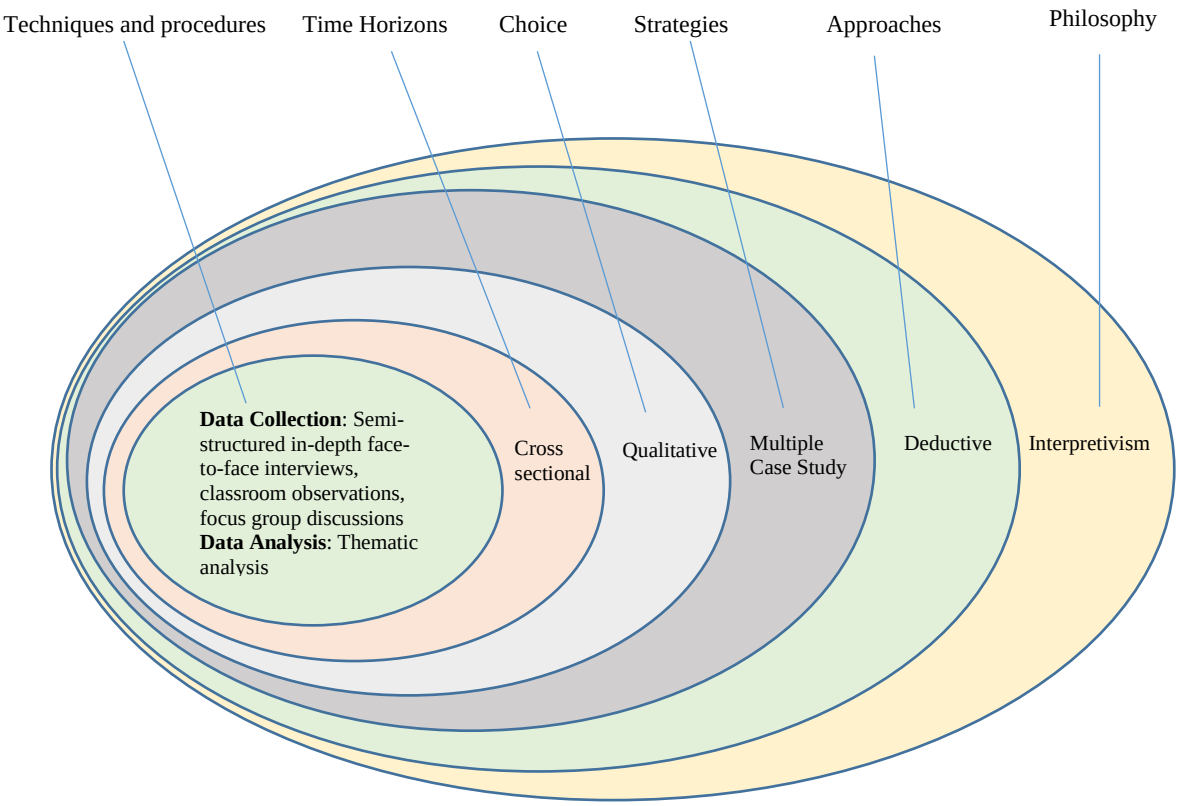

Figure 4.2 The Research Design Summarised (Adapted from Saunders, Lewis & Thornhill, 2012, p. 160)

Whilst working on the analysis of the data it was important to address authenticity in qualitative research.

Ensuring Authenticity of the Study

> *Authenticity means giving a fair, honest and balanced account of social life from the viewpoint of someone who lives it everyday* (Neuman, 2000, p. 171).

In a qualitative study, it is necessary to authenticate the findings because authenticity assists the researcher to establish the trustworthiness, credibility, dependability, transferability and confirmability of a study (Patton, 2002). The extent to which the researcher is able to ascertain confidence in the real value or trustworthiness of the findings is referred to as credibility. This means that in terms of the subjects under investigation as well as the contexts within which the study is conducted, the findings must be true. In this study, the findings emanated from the authentic transcriptions of interviews with Mathematics teachers, one deputy principal, two ICT committee members, one staff member from the Harry Gwala Centre, focus group discussions with Mathematics learners as well as observations of Mathematics lessons.

Transferability and dependability mean that if the same study was conducted under the same or similar conditions, the findings of both studies should be comparable (Neuman, 2014; McNeill & Chapman, 2005). Therefore, transferability may only be established by future researchers.

Confirmability refers to the extent to which the results of a study could be verified or substantiated by researchers. It is "… *concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but are clearly derived from the data*" (Tobin & Begley, 2004 in Anney, 2014, p. 279). A reflexive journal, triangulation and an audit trail contribute to the confirmability of a qualitative study (Lincoln & Guba, 1985). For the purposes of an audit trail, the interviews and focus group discussions were digitally recorded and thereafter transcribed for data analysis. A reflexive journal was kept throughout the data collection process where I reflected upon interviews and observations that were conducted.

To increase the credibility of the results, it is necessary for the researcher to spend an extended period in the field and use diverse methods to ensure triangulation (Flick, 2014; Patton, 2014). Triangulation is an effective method that contributes to the authenticity of data verified from three or more sources. For this study, the requirements of triangulation were achieved by using different sources of data: interviews with Mathematics teachers, focus group discussions with Mathematics learners, classroom observations and the literature review (Patton, 2014).

In addition, the researcher needed to use member checking, requiring one or more participants of the study to verify the accuracy of the data (Creswell, 2013). Once the data from the in-depth face-to-face interviews were transcribed, the transcriptions were emailed to the participants for verification. Some responded indicating that the transcription was a true reflection, while others chose not to, despite reminders being sent out to them. Consequently, it was assumed that the participants did not have any objections and therefore, it was not necessary to make any corrections. Table 4.1 below depicts the various criteria that were applied to authenticate this study.

Table 4.1 Verifying Authenticity in a Qualitative Study (Adapted from Pather, 2005)

CRITERIA	VERIFICATION PROCEDURES	APPLICATION FOR THIS STUDY
Credibility (Internal validity)	Engagement in the field	The researcher spent a specified period at each site.
	Triangulation	Different data sources used: focus group discussions, teacher interviews, observations and literature.
	Member checking	Verification of interview transcripts and participant review of results.
	Reflexivity	Reflective journal kept throughout the research process as part of fieldnotes.
Dependability (Reliability)	Thick description	Thick description of research context and sites.
	Triangulation	Use of different data sources.
	Audit trail	Detailed notes and cross-references kept of data collected and coded using Microsoft Word.
Transferability (External validity)	Thick description	Thick description of research context and sites.
Confirmability (Objectivity)	Triangulation	Multiple data sources.
	Reflexivity	Explanation of the role of the researcher.

Creswell (2014, p. 201) recommended that the researcher:

> *… use a rich, thick description to convey the findings. This description may transport readers to the setting and give the discussion an element of shared experiences. When qualitative researchers provide a detailed description of the setting, for example, or offer many perspectives about a theme, the results become more realistic and richer. This procedure can add validity to the study.*

I followed Creswell's (2014) recommendation regarding the presentation of the findings for this study in Chapters Five, Six and Seven and chose to use the participants' actual words as sub-headings in order not to lose the meaning that they conveyed. In addition, a detailed description of the settings was provided earlier in this chapter.

In the discussion of the findings, contrasting views, opinions and observations were explicitly mentioned and discussed as Creswell (2014, p. 201) advises the researcher to:

> *… present negative or discrepant information that runs counter to the themes. Because real life is composed of different perspectives that do not always coalesce, discussing contrary information adds to the credibility of an account. A researcher can accomplish this by discussing evidence about a theme. A researcher will build a case for a theme, researchers can also present information that contradicts the general perspective of the theme. By presenting this contradictory evidence, the account becomes more realistic and more valid.*

To ensure the reliability of the study, the transcripts of the interviews and focus group discussions were checked several times to verify that no mistakes were made (Gibbs, 2007 in Creswell, 2014). Yin (1994) suggested that to increase reliability more than one observer should be included when observations are being conducted. Therefore, for the observations of the Mathematics lessons, I was accompanied by my mentor, who completed an observation schedule for each one that was conducted. It was important to ensure that a study of this nature complied with ethical considerations as human beings were the participants in this study.

Ethical Considerations

To reiterate, participants in this study were Mathematics teachers, one deputy principal, two ICT members, a staff member from the Harry Gwala Centre and Mathematics learners from three selected Government schools in the Ekurhuleni districts, North, South and East in Gauteng as well as one private school in the Northern Gauteng. The participants were not categorised according to race, age or gender as the primary focus of this study was to investigate the viability of teaching and learning Mathematics in a paperless context. Furthermore, irrespective of race, age or gender, teachers were expected to teach and learners to learn Mathematics in a paperless context. Permission was obtained from the GDE and the private school as well as from the principals of the schools. In addition, permission was requested from the parents of the learners, who had been identified to participate in this study as they were minors during the time of data collection. A letter providing the research topic, the purpose of the study and requesting consent, was distributed to the school principals as well as to those who had agreed to participate. In addition, learners were required to sign an assent form stating their willingness to participate in focus group discussions. Participants were informed that participation was voluntary, and they could withdraw at any time, without any adverse consequences. Furthermore, participants were assured that confidentiality and anonymity would always be maintained as pseudonyms would be assigned to each one and their school.

Participants were assured that no other individual, apart from the supervisor and the researcher, had access to the data and transcriptions as these would be kept safely in a locked cupboard to which only the researcher had access. All audio recordings and transcriptions were saved on the researcher's laptop, which is password protected. Participants would have the opportunity to view the results if requested. After the anticipated successful completion of the study, a copy of the thesis will be emailed to the principals of each site as well as a copy to the GDE.

Summary

In this chapter, the research design and choice of methodology for the study was presented. Additionally, the criteria used for the selection of the research sites and participants were provided. Thereafter, a discussion of the data collection methods, followed by the data analysis, how the study was authenticated, as well as the ethical considerations, which constitute an essential aspect of any study, were presented.

Chapter Five presents Part One of the findings for this study. Similarities or consensus between the data collected and the literature review conducted will be highlighted where necessary.

CHAPTER FIVE

FINDINGS AND DISCUSSION

PART 1: GAUTENG MEC'S STATEMENT ON PAPERLESS SCHOOLS AND THE CONTEXT OF PAPERLESS CLASSROOMS

Introduction

This chapter is the first of three that present the findings that emanated from the analysis of the data collected. The data collected was subsequently analysed using thematic analysis and the following themes emerged.

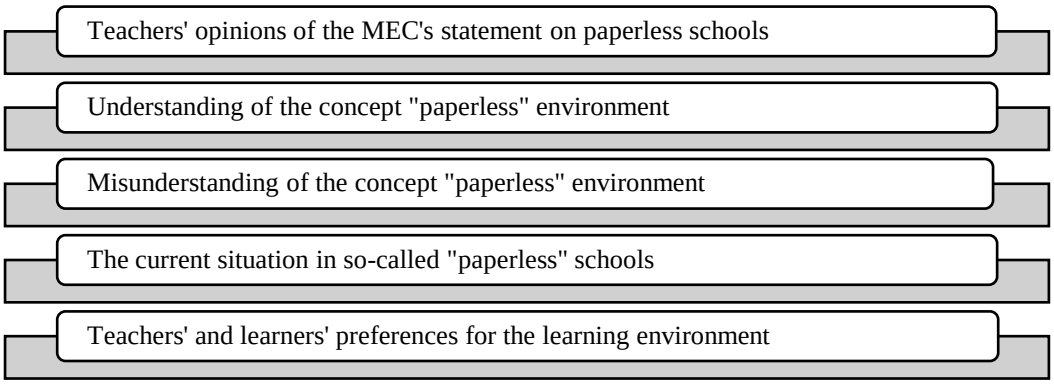

Figure 5.1 Themes on MEC's Statement on Paperless Schools

The discussion begins with teachers' opinions about the Gauteng MEC's statement on paperless classrooms, followed by their understanding of the concept "paperless classroom". It was important that a description be provided of how teaching and learning was conducted in the Mathematics classrooms of the selected paperless cases. Finally, teachers' and learners' preferences regarding teaching and learning in a paperless environment is discussed. Despite some of the excerpts not being grammatically correct, I preferred to use the actual words as expressed by the participants as sub-headings in order not to lose the essence that these words demonstrated. Table 5.1 below provides a summary of participants' phrases that were used to arrive at the open codes as well as the axial code concerning their beliefs about the statement (see Chapter One) made to the press by the Gauteng MEC during the launch of paperless schools. The MEC's statement is important as it clearly reflects what the Gauteng MEC meant

by the term paperless classrooms. Consequently, a discussion of the MEC's statement is central to this chapter.

Table 5.1 Teachers Opinions of the MECs Statement on Paperless Schools

Representative phrases from participants	Open coding	Axial coding
"It's far from reality… I think it was a political statement, it was grandstanding" (Mr Namane). "I think the statement was prematured… we definitely cannot just move from what we know. I mean I've been teaching for the past 22 years and I've been used to the chalkboards, the books, the textbooks and so forth. Now I have to be introduced I think he should have done that gradually" (Mr Nkosi).	Far from reality. Political statement. Premature statement. Educational background.	Teachers opinions of the MECs statement on paperless schools: teachers were of the opinion that the MEC's decision to implement paperless classrooms was unrealistic.
"… paperless is something ICT driven schools are aspiring towards, vision. But you see they took a vision and then they made it a policy, or they made it an immediate goal, it's totally incorrect. That's where the MEC got it wrong because a vision is something that is long term, it's not now. So paperless is still a vision we are still ICT driven schools" (Mr Namane).	Vision.	
"There are problems that [we] were not supposed… [to be] experiencing by now" (Mr Namane). "I don't agree with the statement the MEC has just said because we are still using the chalkboard… because sometimes we have got the challenges… So, I don't know what the MEC… has said is it true or not because really it's not working in our school" (Ms Madi).	ICT Challenges. Blended environment. Disagree with MEC. Not working.	
"… but there was burglaries in our school, cables were destroyed. For 2 years we have been off-line in terms of Wi-Fi. Something as easy as, we have blinds, blinds are destroyed eh, the school must re-install blinds… because it is difficult to see on the board because it reflects, I have been saying this for the past 2 years, you can see that they don't think that if there's the sun, they don't see how difficult it would be for you to use the smartboard, to project something on the smartboard… our school was burgled this year about the fifth burglary … from last year it would be I think more than ten, so this year alone in the space of a month, it's more than five" (Mr Namane).	Theft/burglaries. No Wi-Fi access. Classroom not conducive to use ICTs.	
"… when it comes to reality it is impossible with us, it is very, very difficult to work without those exercise book and chalkboard, we still need them" (Mr Maphosa). 'It's not completely possible, hey. Learners still have to write, to write in their exercise books… they also need to write their assignments on papers and hand in those papers" (Ms Shabangu). "I don't know how they will entirely do away with the paper, but to me, we still do need eh, a book a pen" (Mr Nkosi).	Paperless classroom impossible. Writing/exercise books necessary.	
"… we didn't go 100% paperless, but up till now some of the learners are not coping with the textbook in their tablets. Some feel more comfortable with the normal textbook" (Mr Mbatha).	Learners not coping. Hardcopy textbook preferred.	

"… when it was introduced, I don't think eh, a study was conducted on who has the qualifications for this and how is it going to work in our schools, especially the location schools" (Mr Sangu).	Prior research not conducted on qualifications.	
"Technology has not yet played that big role in convincing learners about passing Maths… technology is just a method of teaching to me. So, this thing of convincing learners about eh the possibility of passing Maths, it has to do with the teacher… the teacher must have different strategies… that he or she must use to convince learners so that they can pass Maths" (Mr Khoza).	Technology vs. learners' results. Teaching strategies.	
"I don't agree at all… the story between Mathematics and Maths Lit … goes beyond this technology use. A major problem is… everything about Grade 9, the syllabus, the quality of teachers that we have" (Ms Mbheki). "I make a joke of it, if ever I become something in South Africa and I have a say, I will take all the syllabi we use for Grade 9, put them in the fire, start over again. Grade 9 should be for me… we should talk about basics… introduce each topic… you see if we are just introducing, we won't lose the children" (Ms Mbheki). "We make it so hectic that the children give up, especially because they know that there is an option. But most of the kids that go to Maths Lit is because they have given up on Maths" (Ms Mbheki). "No, honestly I don't quite see a relationship there because mainly it is just based on the learner and the commitment of the learner" (Ms Shabangu).	Subject choice. Grade 9 curriculum Mathematics vs. Maths Lit.	

"It was a political statement"

"… it's far from reality, very far. I think it was a political statement, it was grandstanding". The above statement clearly indicates the opinion of Mr Namane from Iziphethu Secondary School regarding the Gauteng MEC's statement. He added, "*I think politicians they put us in trouble at times, they put us in trouble and their expectations are not realistic*". Mr Namane was adamant that the concept "paperless schools" was the MEC's vision as is evident from the following statement:

> *… paperless is something ICT driven schools are aspiring towards, vision. But you see they took a vision and then they made it a policy, or they made it an immediate goal, it's totally incorrect. That's where the MEC got it wrong because a vision is something that is long term, it's not now. So paperless is still a vision we are still ICT driven schools*.

What Mr Namane has mentioned aptly describes the current situation in the four cases where this study was conducted since these schools are interspersing ICTs with the traditional methods of teaching and learning. From the observations conducted as well as the interviews with the Mathematics teachers, and the focus group discussions with the Mathematics learners, it was evident that Mathematics was not being taught in a paperless context, and the Gauteng

MEC's "vision" of teaching and learning in a paperless environment by 2018, had not been realised. The Gauteng MEC appeared to be confident that Gauteng schools would be paperless by 2018, however, as indicated above this is not the case. Mr Namane added that they were experiencing numerous problems regarding the use of technology, which he believed that they should not be because it was four years (data were collected in 2018) since the inception of paperless schools in 2015, *"... but by now there are things that we, there are questions that we should not be even asking by now. There are problems that [we] were not supposed… [to be] experiencing by now*". Ms Madi, who is a colleague of Mr Namane, was resolute when she pointed out:

> *I don't agree with the statement the MEC has just said because we are still using the chalkboard … because … this thing of paperless it has got the disadvantage and advantage… because sometimes we have got the challenges… because really, it's not working in our school.*

The Gauteng MEC was adamant that the chalkboard, chalk and exercise books would not exist in a paperless classroom any longer. However, in the above excerpt, Ms Madi emphasised the importance of the chalkboard remaining in the classroom because she used this when technology failed to meet her needs. It is important to point out that all participants indicated that the chalkboard/whiteboard was removed when smartboards were installed, despite teachers requesting that these remain fixed to the walls in their classrooms. Although the chalkboard/whiteboard was removed, I observed that some of the teachers had either a chalkboard/whiteboard propped up loosely next to the smartboard should the use of technology fail to meet their needs, which was precisely the case in Ms Madi's situation.

The TCK component of the TPACK conceptual framework, focuses on classroom management challenges regarding the use of technology during teaching and learning. During the interviews the participants pointed out that when technology is used in teaching and learning, the management of such infrastructure was a major challenge, for example, the smartboard not working, no electricity and learners' broken, lost or stolen tablets. This is evident in the following excerpt:

> *… but there was burglaries in our school, cables were destroyed. For 2 years we have been off-line in terms of Wi-Fi. Something as easy as, we have blinds, blinds are destroyed, the school must re-install blinds for example, because it is difficult to see on the board because it reflects. I have been saying this for the past 2 years, you can see that they don't think that if there's the sun, they don't see how difficult it would be for you to use the smartboard, to project something on the smartboard... our school was burgled this year about the fifth burglary, alone, yes, I'm counting this year alone. From last year it would be I think more than ten, so this year alone in the space of a month, it's more than five* (Mr Namane).

In Makwela's (2019) study that was conducted at two township paperless schools in Gauteng that were not included in this study, revealed that electricity outages posed a major challenge to teachers as all devices used in the classroom required electricity. In addition, many of the learners in her study mentioned that they had to leave their tablets at school because they feared that if they took them home, they would be stolen. In a paperless environment, according to the Gauteng MEC, there would be no place for the hardcopy textbook nor the exercise book in the classroom. Considering that theft is rife in South Africa and that learners are afraid to take their tablets home, how then are these learners supposed to complete their homework or study for their assessments if no pen and paper are used? The above discussion, therefore, questions the viability of teaching and learning in a paperless environment and proves that even with the advances in technology, pen and paper will continue to remain a necessity in education. This inference is based on the fact that there are diverse challenges experienced in South Africa, such as theft as well as other socio-economic factors, some due to unequal opportunities whereas others due to a lack of adequate income in the household. Since 2015, when paperless schools were established, there have been numerous robberies of smartboards and tablets. At one of the paperless schools that began this project in January 2019, all the electronic equipment was stolen (Naidoo, 2019). A parent voiced their concern regarding the issue of theft at this school:

> *My son is doing Grade 7. It's going to be difficult for them. All of the Grade 7's and the teachers as well, because they don't have textbooks. They were using tablets, but now they took all the tablets. They took everything. So, now we are not safe here. The security is too poor, especially during the day. There's nobody here. We feel very sad because this thing is very, very, very bad. The Department of Education was supposed to put a tight security.*

It is apparent from the parent's excerpt that contingency plans were not in place in the event of a burglary to ensure that teaching and learning could continue. If hardcopy textbooks had been available, teaching and learning could have continued, even though these were so-called paperless schools as pen and paper were still being used. The question on the viability of teaching and learning in a paperless context arises once again; the theft of the technological devices renders a paperless classroom as non-viable since no teaching and learning can happen in a paperless context without technology. Providing adequate security to ensure that the electronic equipment at the respective schools was secure, should have been a priority of the DoE, considering that this is not the first incident of theft of tablets and smartboards. However, it seems that the DoE is not concerned as pointed out by the above parent as well as Mr Namane,

who also complained about the DoE providing the technology but not providing the necessary security at these so-called paperless schools (see Chapter Six).

According to Koehler and Mishra's (2009) TPACK conceptual framework, in order to use technology for teaching and learning, teachers are required to possess advanced knowledge on how the selected technology works. They should be able to "trouble-shoot" when technological problems arise, thus ensuring a seamless teaching and learning process. The DoE has provided technological support by establishing a support centre, referred to as "The Harry Gwala Centre" at two of the selected cases. However, the support provided does not adequately satisfy the needs of the teachers timeously as is evident from the interview with one of the Harry Gwala technicians:

> *By troubleshooting I mean like we troubleshoot each and every board around the school, checking what's the problem. Should it have any hardware issue, or any software issue, we note it down. So today we are busy troubleshooting, and this is now the list that I have to send to the GDE so that they can send another technician to come and fix all these problems that they are having.*

From the above excerpt, it is apparent that there would be a time delay between the GDE receiving the request and attending to the problem, consequently, questioning how teachers are expected to continue teaching in a paperless environment when the technology is not available. Therefore, the Gauteng MEC's statement regarding the removal of the chalkboard/whiteboard as well as the use of pen and paper from the classroom is unrealistic, as the participants have indicated. If teaching and learning were to take place solely with the use of technology in a paperless context, then no teaching and learning will be affected in the event of technological problems. The literature review in Chapter Three highlights that not all subject content can be taught using technology, similarly not all content can be taught using the same teaching style. It is, therefore, important that one takes cognisance of Spangenberg's (2017, p. 105) advice regarding the use of technology; "… *using technology with every activity and for every instructional purpose is just as futile as using direct instruction for every topic and lesson".* This is precisely what would happen if teaching and learning were to be conducted in a paperless context, solely with the use of technology. As early as 1997, Sandholtz, Ringstaff and Dwyer indicated that the overuse of technology, as well as the infrequent and inappropriate use, could have negative consequences, resulting in learners being frustrated, bored or distracted. It is important to point out that the above challenge would not be present when teaching in a blended environment, which is the use of the traditional face-to-face instruction

combined with the integration of technology where necessary. In a blended environment, teachers have the choice of how to present the subject content as well as the tools they may use to teach and for learners to learn. Consequently, retaining the use of pen and paper, the chalkboard/whiteboard and integrating technology when appropriate, would provide a diverse learning environment where teaching and learning would continue irrespective of the technological problems experienced. The use of a blended teaching and learning environment may possibly ward off the concerns regarding the over-use and inappropriate use of technology by teachers.

Mr Nkosi, a colleague of Ms Madi and Mr Namane, believed that the MEC's statement was untimely as indicated in the following statement:

> *I think the statement was prematured in a sense that uhm, we definitely cannot just move from what we know. I mean I've been teaching for the past 22 years and I've been used to the chalkboards, the books, the textbooks and so forth. Now I have to be introduced I think he should have done that gradually*.

It is evident that both Mr Nkosi and Mr Namane believed that the Gauteng MEC was overly ambitious in his statement to the press and that he could not expect them to transition to teaching and learning in a paperless environment "overnight". Mr Maphosa from Isilomo Secondary School, who has a considerable number of years of experience in teaching Mathematics, stated categorically that *"... when it comes to reality it is impossible with us, it is very, very difficult to work without those exercise book and chalkboard, we still need them*". Ms Shabangu from Illungelo Secondary School, who has vast experience with the use of technology, concurred with Mr Maphosa "… *it's not completely possible, hey. Learners still have to write, to write in their exercise books, they have to write in their exercise books and they also need to write their assignments on papers and hand in those papers*". Mr Nkosi stated emphatically "*I don't know how they will entirely do away with the paper, but to me, we still do need eh, a book, a pen*" and Mr Mbatha added *"... we didn't go 100% paperless, but up till now some of the learners are not coping with the textbook in their tablets. Some feel more comfortable with the normal textbook*". The above excerpts clearly provide evidence that teachers are teaching in a blended environment where technology is used when possible, as well as pen and paper, and the chalkboard/whiteboard. It is important to point out that teachers are adamant that the exclusion of the chalkboard/whiteboard and pen and paper is not a possibility, and definitely not a reality in these so-called paperless schools.

The TCK component of the TPACK conceptual framework encompasses teachers' comprehensive knowledge and understanding that is used to select the appropriate technology to enhance teaching and learning (Mishra & Koehler, 2006). In this regard "… *teachers need to know not just the subject matter they teach but also the manner in which the subject matter can be changed by the application of technology*" (Mishra & Koehler, 2006, p. 108). Like Mr Nkosi, the majority of the teachers in this study did not have a comprehensive knowledge and understanding of the use of technology to teach Mathematics because they were accustomed to the use of the chalkboard/whiteboard. The use of technology was thrust upon them without adequate preparation for this transition. It is obvious from the above discussion that the participants believed that Mathematics cannot be taught solely using technology, hence questioning the viability of teaching and learning Mathematics in a paperless environment, as envisioned by the Gauteng MEC.

To re-emphasise, the Gauteng MEC anticipated that all schools would be paperless by 2018, however, the above evidence indicates that paperless schools are not in existence in Gauteng despite it being 2020. This begs the following questions; *Was there any intensive research conducted into paperless classrooms to establish the viability of teaching and learning in a paperless context*? *Were teachers consulted regarding the viability of teaching and learning Mathematics in a paperless context*? In Mr Sangu's opinion, an experienced Mathematics teacher from Iziphethu Secondary School, teachers were not included in the initial stages of planning for paperless classrooms; *"When it was introduced I don't think, a study was conducted on who has the qualifications for this and how is it going to work in our schools, especially the location schools*". A study conducted by Matwadia (2018) that included teachers from paperless schools as participants, confirmed Mr Sangu's doubts that teachers were not included in the decision to transition to paperless classrooms. Considering that teachers are expected to drive this initiative, they should have been involved in all discussions and planning from inception.

The Gauteng MEC in his address to the media claimed that as a result of the use of technology in teaching and learning, learners would choose pure Mathematics instead of Mathematical Literacy as a subject (Magubane, 2015). The next section deals specifically with teachers' responses to the Gauteng MEC's statement regarding subject choice.

"Most of the kids that go to Maths Lit … have given up on Maths"

Mr Khoza from Isilomo Secondary School refutes the Gauteng MEC's statement on subject choice:

> *Technology has not yet played that big [a] role in convincing learners about passing Maths… technology is just a method of teaching to me. So, this thing of convincing learners about the possibility of passing Maths, it has to do with the teacher… the teacher must have different strategies… that he or she must use to convince learners so that they can pass Maths*.

As Mr Khoza mentioned in the above statement, the use of technology will not influence learners' choice of pure Mathematics instead of Mathematical Literacy. To be more precise, it would be the teachers' pedagogical knowledge (PK) that would play a vital role in learners' subject choice. The conceptual framework known as TPACK that underpinned this study, indicates specifically that teachers should have a sound understanding of when and how to use technology as well as the pedagogical knowledge (PK), to determine whether the use of the selected technology will enhance the teaching and learning of specific Mathematical concepts. As a former Mathematics teacher, I concur with Mr Khoza that when I attended secondary school, which was in the 1980s, no digital technology was used in teaching and learning. However, it was solely my teacher's passion for Mathematics and his excellent teaching style that influenced my choice of studying Mathematics on the Higher Grade; at that time, we had a choice of studying Mathematics either on the Higher or Standard Grade. Furthermore, my teacher displayed a great degree of PK and CK to teach the Mathematical content, which consequently influenced my choice to study Mathematics and qualify as a secondary school Mathematics teacher.

Ms Mbheki from Illungelo Secondary School, who has over thirty-five (35) years of teaching experience, is emphatic in her response to the Gauteng MEC's statement regarding subject choice:

> *I don't agree! I don't agree at all! It doesn't make a difference, yes, the children are … interested in anything that comes to technology because I mean it gives them an opportunity to bring out their tablets and phones and all that. But the story between Mathematics and Maths Lit to be completely honest with you goes beyond this technology use. A major problem, I don't know how far this will go, is Grade 9. Everything about Grade 9, the syllabus, the quality of teachers that we have*.

It is obvious from the above statement that Ms Mbheki acknowledges that learners enjoy the use of technology, however, she emphasised that it is the content of the Grade 9 curriculum as

well as the competence of the Mathematics teachers that would influence learners' subject choice between pure Mathematics and Mathematical Literacy. She added:

> *I make a joke of it if ever I become something in South Africa and I have a say, I will take all the syllabi we use for Grade 9, put them in the fire, start over again. Grade 9 should be for me … we should talk about basics, don't talk too much about any topic, introduce each topic … then let's see how, you see if we are just introducing, we won't lose the children. In Grade 9, we introduce Algebra, we go all the way to factorising the difference of two squares in Grade 9. I don't see why we need to do that; the trend so far is that 80% of our learners want to go to Math Lit.*

Ms Mbheki is also of the opinion that it is not the use of technology that would influence a learner to choose pure Mathematics as a subject, instead a complete restructuring of the Grade 9 curriculum is a necessity. Cognisance should be taken of Ms Mbheki's observation and suggestion regarding the restructuring of the Grade 9 Mathematics curriculum, considering her vast experience and knowledge of the subject matter. She consequently offered her thoughts on how she would like to teach pure Mathematics to her Grade 9 learners:

> *When I start algebra in Grade 9, allow me to touch on the things that are a little bit more interesting. Let's see how many children I don't lose because it's getting hectic, so I can hold their interest until the end of the year so that I don't get to the end of Grade 9 with learners who have already made up their mind that they can never pass Mathematics. That's what's happening now, that is exactly what is happening. We make it so hectic that the children give up, especially because they know that there is an option. But most of the kids that go to Maths Lit [choose it] is because they have given up on Maths.*

Ms Mbheki is adamant that learners' subject choice is based on the difficulty of the Grade 9 Mathematics curriculum, which influences learners' choice of Mathematical Literacy instead of pure Mathematics. Considering the vast Mathematical teaching experience that Ms Mbheki possesses, her reasoning for learners' choice of Mathematical Literacy appears to be more convincing than the MEC's statement that the use of technology would influence learners to choose Mathematics. Ms Shabangu added:

> *No, honestly, I don't quite see a relationship there because mainly it is just based on the learner and the commitment of the learner … there are some learners who choose to decide to do pure Maths, but they are not disciplined. They don't really want to work and obviously, in pure Maths you need to have work ethics, you need to be able to do all the assigned work, but some learners do not have that commitment which is the main reason why they end up moving onto Maths Lit.*

In addition to the reasons provided by Ms Mbheki that influence learners' choice of Mathematical Literacy, Ms Shabangu stated that because pure Mathematics requires learners to be continuously engaged with the subject content, learners opt for Mathematical Literacy, due to a lack of commitment. It is important to note that all participants in this study concurred that technology will not influence learners' choice of Mathematics as a subject. A study conducted at a Secondary School in Kwa-Zulu Natal, South Africa, investigating the factors

influencing learners' choice of Mathematics in Grade 10 revealed that learners do not choose pure Mathematics as a subject because of the following reasons: "*Mathematics anxiety; perceptions that Mathematics is boring and difficult to understand; classroom pedagogy [PK]; teacher attitudes; career aspirations; parental pressure; and course selection limitations*" (Govender, 2012, p. iii). Another study conducted by Marchis (2011) in Romania, investigated learners' attitudes towards Mathematics, and identified the teacher as the main influence:

> *... the teachers' attitude to Mathematics and the amount of confidence and support he/she gives to the pupil influence their attitude towards Mathematics. Another important factor is how pupils think about the utility of Mathematics in their everyday life. Self-efficacy and self-judgment also influence pupils' attitude towards learning Mathematics* (Marchis, 2011, p. 786).

The Talis Report (Teaching and Learning International Research Study) that explored the circumstances of teaching and learning in forty-eight countries worldwide, found that one of four teachers at South African schools do not have a Higher Education qualification (Kubheka, 2019). The mere fact that teachers do not have the necessary qualifications to teach Mathematics is a major concern as it would imply that they do not have the requisite content knowledge (CK) to teach the subject. Subject content knowledge is central to teaching and learning according to Shulman (1986) in Koehler and Mishra (2009, p. 63) since it comprises:

> *… knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge. Knowledge and the nature of inquiry differ greatly between fields, and teachers should understand the deeper knowledge fundamentals of the disciplines in which they teach*.

The above findings in the Talis Report may contribute to learners not choosing pure Mathematics as a subject. At this point it is important to provide a discussion on the participants' understanding of the concept "paperless" classroom. Table 5.2 below is a summary of participant's excerpts that were analysed, resulting in the open codes as well as the axial code. A discussion of the theme "Understanding of the concept 'paperless' environment" follows immediately after the table.

Table 5.2 Understanding of the Concept 'Paperless' Environment

Representative phrases from participants	Open coding	Axial coding
"… it simply means that the full use of ICT in Education… you are not supposed to use paper. That concept entirely uhm really means that I when I give learners my activities, they supposed to do it online and I am supposed to mark it and report to learners online… the full use of and implementation of ICTs" (Mr Namane).	Full use of ICTs. No paper. Complete activities online.	Understanding of the concept "paperless" environment: the majority of the teachers and learners had a clear comprehension of what the MEC meant by a "paperless" classroom.
"… according to my understanding, when they say it's, the school is paperless, I think we need to use everything electronically, you don't need paper anymore, but while we still use them in Mathematics" (Ms Madi).	Everything electronic. No Paper.	
"Paperless class as it says you don't use paper, purely rely on ICTs… without using any hardcopy, purely ICTs" (Mr Mdluli).	Rely purely on ICTs. No hardcopies.	
"I'm saying this could basically [be] the use of technology… as it says it's paperless, we are doing away with paper and making use of technology" (Mr Museba).	Technology-use only.	
"… paperless classroom, what I do understand is that we are no longer going to use exercise books, when they, we must do answers either classwork or homework we gonna use their tablets, that's what I understand about paperless" (Mr Maphosa).	No exercise books. Use tablets.	
"… it means we are completely eliminating paper and substitute it with electronic devices … just a complete elimination of paper" (Mr Mbatha).	Elimination of paper.	
"I was expecting… we email our teachers our work, we only bring our tablets to school, we type down everything and then email everything" (learner).	Email work to teacher	

"[In a] paperless class … you don't use paper, purely rely on ICTs."

The above statement indicates emphatically that in a paperless classroom there is no use of pen and paper but a reliance purely on ICTs. From the statement issued by the Gauteng MEC regarding paperless schools, it is evident that the concept paperless school as envisaged by the Gauteng MEC is that no pen, nor paper, no chalkboard, nor chalk, will be used in a paperless classroom. The majority of the participants, both teachers and learners, understood the concept of paperless classrooms as expressed by the Gauteng MEC, however, there were a few participants who had a different understanding of paperless classrooms, which will be discussed later. The following is an excerpt from the interview with Mr Namane where he explained his understanding of a paperless classroom:

> *… it simply means that the full use of ICT in Education, for example, using of the smartboard and the tablets and to ensure that we synchronise what's happening on the smartboard with what's happening on the learner tablets. When you give them… activities you are not supposed to use paper, you know, they are supposed to take it directly from the smartboard, and from the teacher, the laptop. That concept entirely … means that I when I give learners my activities, they supposed to do it online and I am supposed to mark it and report to learners online. That's what I understand by the paperless classroom, the full use of and implementation of ICTs.*

Mr Namane is an ICT committee member, who is responsible for and drives the implementation of ICTs at Iziphethu Secondary School. It is evident that Mr Namane has a clear understanding of the MEC's statement regarding teaching and learning in a paperless classroom. Being an ICT committee member, who is responsible for the effortless implementation of ICTs at his school, it is Mr Namane's responsibility to ensure that all teachers at his school have a common understanding of what a paperless environment, entails. All three Mathematics teachers interviewed at this school had a clear comprehension of the concept paperless classrooms and agreed that in such an environment pen and paper as well as the chalk, chalkboard or whiteboard is not a component. This is evident in Ms Madi's statement "*… according to my understanding, when they say it's, the school is paperless, I think we need to use everything electronically, you don't need paper anymore, but while we still use them in Mathematics."* Mr Sangu added, "*What I expected is, I was supposed to have my test, class test or whatever test, then I just send it to them [learners], then they just write it and they send it back, then I mark it, then I give them the feedback, that's what I understood*".

In addition, the teachers from Intaba Secondary School, the second case study, displayed a clear understanding of the concept paperless classrooms as is apparent from the following excerpts. Mr Mdluli said "*Paperless class as it says you don't use paper, purely rely on ICTs, like currently, we are using smartboards, the kids are using, tablets. So, basically, that's the interaction of learners without using any hardcopy, purely ICTs*". Mr Museba's understanding of paperless classrooms corresponds with the concept of a paperless environment "*I'm saying this could basically [be] the use of technology… where, as it says it's paperless, we are doing away with paper and making use of technology*". Mr Maphosa concurred with the above-mentioned participants in his understanding of a paperless classroom "*… paperless classroom, what I do understand is that we are no longer going to use exercise books … we must do answers either classwork or homework we gonna use their tablets, that's what I understand about paperless".*

Another participant who clarified his understanding of the concept "paperless classrooms" and echoed the sentiments of the Gauteng MEC, is Mr Mbatha from Illungelo Secondary School:

> *… it means we are completely eliminating paper and substitut[ing] it with electronic devices like in our case we [are] using tablets and most of the things we used to photocopy, now will be put into one gadget … that's basically just a complete elimination of paper … we are using tablets.*

The fact that the above participant used the word "eliminate" is significant because it suggests the exclusion of pen and paper and anything to do with the use of paper resulting in a paperless environment. It is evident from the above excerpts that these participants have a lucid understanding of what is required in a paperless environment yet it is five years later since the inception of paperless schools in Gauteng and none of the teachers at the selected cases are indeed teaching Mathematics in a paperless context. In fact, evidence provided by Mathematics teachers, Mathematics learners as well as the classroom observations, revealed that the use of pen and paper are still predominantly used in the Mathematics classroom at all these sites. A learner expressed her expectations prior to attending this "so-called" paperless school "*I was expecting… we email our teachers our work, we only bring our tablets to school, we type down everything and then email everything but when I got here I just realised the only difference is, to our school and the school I come from is, it's only the projectors and the smartboard and that's it".*

Despite the above-mentioned participants having a clear understanding of the concept paperless classrooms, it was not possible for them to conduct teaching and learning in a paperless environment, due to diverse challenges they experienced, which will be discussed in detail in Chapters Six and Seven. Since there were three participants at the selected sites, who did not share the same understanding of what a paperless classroom entails, it is necessary to provide a discussion on their interpretation of a paperless classroom. Table 5.3 below illustrates the open codes as derived from the excerpts from these participants' interviews, followed by a discussion.

Table 5.3 Misunderstanding of the Concept "Paperless" Environment

Representative phrases from participants	Open coding	Axial coding
"Paperless it's whereby we are reducing the maximum of paper that we are using" (Ms Mashego). "… paperless obviously using less paper in schools" (Ms Smit).	Reduction in paper usage.	Misunderstanding of the concept "paperless" environment: some teachers and learners understood "paperless" classrooms as the reduction of the use of paper.
"I feel like this paperless school would kind of take away teachers, I mean like soon we won't be having teachers and we would be learning on technology … and it's very difficult to … ask questions" (learner). "… if you go to paperless most teachers lose their jobs because there won't be a need for them to teach" (learner).	Misconception: No need for teachers in a paperless environment. Teachers/loss of jobs.	

"Reducing the maximum of paper"

"*Paperless it's whereby we are reducing the maximum of paper that we are using*". This excerpt was taken from the interview with Ms Mashego from Isilomo Secondary School, which indicated a misconception of a paperless classroom. In her interview she pointed out that her classroom was the first paperless classroom in the school. However, I observed that she used the chalkboard, which confirms her misconception of the concept of a paperless classroom. This begs the question, "*How could her classroom have been the first paperless classroom if she still uses the chalkboard?"* Additionally, what is interesting is that Ms Smit and Ms Baloyi from Illungelo Secondary School, share this misconception regardless of their school being the precursor to paperless schools. Ms Smit stated that "… *paperless obviously using less paper in schools … is sometimes a problem*". Considering that Illungelo Secondary School was the first to pursue the paperless route, all teachers should at this point have had a clear understanding of the concept paperless classrooms as relayed by the Gauteng MEC. As a member of the ICT committee, it would be essential that Ms Smit has the correct understanding of paperless classrooms for her to drive the implementation of a paperless context.

Learners from Intaba Secondary School also demonstrated a misunderstanding of a paperless classroom as well as how teaching and learning would take place in such an environment. Their understanding is that there will be no teachers in a paperless classroom as is evident from the statements below:

> *I feel like this paperless school would kind of take away teachers, I mean like soon we won't be having teachers and we would be learning on technology… and it's very difficult to… ask questions.*
>
> *… if you go to paperless most teachers lose their jobs because there won't be a need for them to teach.*

These learners have the misconception that teachers will be removed from this equation (to use Mathematical terminology), however, this is not the case as teachers will still be required to teach in a paperless environment. Based on learners' misconceptions of teaching and learning in a paperless environment, a question was posed on whether they would cope without a teacher in the classroom or not, to which they responded:

> *… for me personally, I think I wouldn't cope, and I would need a teacher to help me out.*
>
> *I wouldn't cope without a teacher; I need someone to explain and show me which way to go and I need someone to guide me.*
>
> *I think people cannot learn without a teacher.*

From the above, it is apparent that technology cannot replace the human factor, which is the teacher in the classroom. Consequently, it is evident that both teachers and learners see the human factor as an important component of teaching and learning. Therefore, a blended environment would be most suitable as mentioned in their preferences.

Mr Sangu pointed out "*So the paperless, it is not paperless, it's paper-full*". Drawing upon Mr Sangu's sarcasm in the above comment, it is essential that the actual situation in schools that are identified as paperless, be discussed. Table 5.4 below depicts teachers' and learners' expressions regarding how teaching and learning was being conducted in the Mathematics classroom, followed by a discussion of the actual classroom situation in the four cases that were investigated for this study.

Table 5.4 The Current Situation in so-called "Paperless" Schools

Representative phrases from participants	Open coding	Axial coding
"It's not really paperless" (Ms Mbheki). "As I said there's no paperless" (Mr Sangu). "… for now, we are not 100% paperless" (Mr Thoko). "We are not totally a paperless school" (Ms Smit). "… so, it's not really paperless as it's going" (Ms Mbheki). "I thought that… this school there won't be anything to do with paper (learner). We will only use our tablets or laptops, computers, yes only but the time I arrive here at school I saw papers and I was confused" (learner). "… for me paperless classroom it's not really, really paperless, because children are still writing in their books" (Ms Vermaak). "… we still use the exercise books; we also use the tablets… we cannot do away with the exercise books" (Ms Sedibe). "… on Maths it's like we are still using the old system because we are still using papers because we are making copies for learners, it's not paperless" (Ms Madi). "… it's 40% paperless at the moment" (Mr Namane).	Not paperless. Writing in books. Blended environment. Hardcopies.	The current situation in so-called "paperless" schools: teaching and learning of Mathematics at these so-called "paperless" schools are being conducted in a blended environment where the use of pen and paper dominates the classroom experience.
"We don't usually use our eh tablets when we are doing Maths... all we do [with] tablets, just capture pictures" (learner). "… most of the time the teacher is explaining the work on the board, she doesn't tell us to take out the tablets and work" (learner). "I use eh my tablet for textbooks and other resources, but the learners use their… exercise books for their workbooks, for classwork and other exercises" (Mr Bhengu).	Tablet use in Mathematics/access textbook and take pictures of work on the smartboard.	
"I like the fact that we are… using paper, notebooks and this technology thing together" (learner). "… we [are] blended because sometime[s] you can find there's load-shedding… so whenever there's no electricity, the smartboard is not working so we use textbooks [hardcopies]" (learner). "… personally, in my lessons, I'm not paperless as it were. I combine both technology and old school" (Mr Museba).	Blended environment. Hardcopies.	

"Teachers still write on the board and we're supposed to copy what they write down and nothing has been changed … not much has changed as we downloaded the notes and whatever but not much of a change compared to the chalkboard in my Maths" (learner).	Context/no change.	
"… there are still some of them [teachers] using the smartboard as just a substitute for a blackboard… we still administer tests and exams… using paper… learners… still, write in their books. So, we haven't really completely eliminated paper" (Mr Mbatha). "… we don't have the assessment which are on the tablets… all the assessments are still paper… we need to make copies, each and every time if you want to do the SBAs everything. We need to make copies of those activities" (Ms Madi). "… so, I think… we are still using the old system because on the smartboard we are just writing… I'm explaining, writing and erasing" (Ms Madi). "… the biggest problem we have is our learners still need to keep our writing function in schools because the Matrics still write their exams [on paper]" (Ms Smit).	Smartboard/ substitute for the blackboard. Paper-based assessment. No assessments on tablets.	
"… so now again Mathematics with the caliber of learners we have in our school, you really have to explain to them. So, now just to give them something to do on their own there, it was a big challenge. So, at the end of the day, we are still using the board to teach them" (Mr Mdluli). "It depends on the type of learners that a school has … in a setup like ours where you are teaching learners maybe with 3% in Maths … we need blended, maybe it will take time, but we need a blended one, yes" (Mr Mdluli).	Learners' abilities in Mathematics. Blended environment.	

"It's not really paperless"

The above sub-heading identifies the actual situation in all the participating cases. When participants were asked to describe their understanding of a paperless classroom, they described the actual classroom situation, which indicated that these classrooms were not truly paperless. Below are statements from focus group discussions held with learners at the four sites:

> *I thought that… this school there won't be anything to do with paper. We will only use our tablets or laptops, computers, yes only, but the time I arrive here at school I saw papers and I was confused. I don't know why because this school they were saying we were going to use technology.*
>
> *We don't usually use our eh tablets when we are doing Maths... tablets we using it to… capture pictures from the smartboards as you've seen, only. We not using it, calculator from the tablets because we using Casio. That's all we do [with] tablets, just capture pictures.*
>
> *… most of the time the teacher is explaining the work on the board [smartboard], she doesn't tell us to take out the tablets and work.*

To reiterate, Gauteng paperless schools were established in 2015, the focus group discussions were conducted in 2018 and to date, all the cases in this study are not functioning in a paperless context. However, teaching and learning is being conducted in a blended environment as

confirmed by one of the learners "*I like the fact that we are… using paper, notebooks and this technology thing together*". During classroom observations that were conducted after the teacher interviews and focus group discussions with learners, the above statements were verified as I witnessed how learners used their tablets during Mathematics lessons, which was merely to take photos of the work displayed on the smartboard or to access the textbook. At none of the sites was it evident that the tablets were used to actively engage learners with the Mathematical content nor was it used to teach Mathematics except in the manner as described above. Additionally, one learner pointed out:

> *Teachers still write on the board and we're supposed to copy what they write down and nothing has been changed…not much has changed as we downloaded the notes and whatever but not much of a change compared to the chalkboard in my Maths.*

What is evident from the above excerpt is that teachers are merely using the smartboard as a replacement for the chalkboard/whiteboard. The fact that a learner says "*not much has changed*" is of concern, especially since substantial funds have been invested to establish these paperless schools. The Gauteng MEC continued to "boast" to the media that teaching and learning at these schools will be conducted exclusively with the use of technology and there will be no need for the pen and paper nor the exercise books; yet what is happening in these paperless schools is contrary to what is being promoted by the Gauteng MEC. In fact, it is not the Gauteng MEC alone that continues to "boast" about these so-called paperless schools, but other members of the African National Congress (ANC) also labour under the misconception that because smartboards were installed in these schools, learners were provided with tablets and the school had access to Wi-Fi, teachers would automatically transition to teaching and learning in a paperless context. Taking cognisance of the above discussion, Mr Namane's statement "*I think it was a political statement, it was grandstanding*", does not appear to be implausible.

Ms Baloyi felt that the MEC wanted Gauteng schools to be paperless, but this is not the case. She indicated that in some instances you have to use paper so that learners can practice. This may suggest that Ms Baloyi has the requisite Technology Knowledge (TK) as she indicates that at times technology would not suffice. Having the ability to realise when technology may be used to the advantage of learners and knowing when not to use it, is important because it can aid or hinder the attainment of an objective (Koehler & Mishra, 2009). A colleague of Ms Baloyi, Ms Vermaak added:

> … f*or me paperless classroom it's not really, really paperless, because children are still writing in their books… paperless to us with technology is basically to move away from your textbooks … in that respect paperless, yes definitely because then they use their tablets where the textbooks are downloaded.*

It is evident from the above statement that Ms Vermaak relates the concept "paperless" to the availability of textbooks on learners' tablets and not the entire teaching and learning process. Mr Mbatha, the ICT committee member and Deputy Principal at the same school, who is also responsible for spearheading the concept of paperless classrooms professed that:

> *… there are still some of them [teachers] using the smartboard as just a substitute for a blackboard. Although I would like to believe it is a paperless environment but it's not completely paperless at the moment because we still administer tests and exams the old way you know, so we still using paper in that regard and also learners for doing homework they still write in their books. So, we haven't really completely, eliminated paper.*

This situation in a so-called paperless classroom, as revealed by Mr Mbatha, was apparent in all the observations conducted in Mathematics classrooms, where teachers substituted the smartboard for the chalkboard and learners wrote extensively in their exercise books. Ms Madi agreed "*… we are still using the old system because on the smartboard we are just writing, there is nothing that we, I can say is electronical… I'm explaining, writing and erasing*". Ms Smit concurred "*we are not totally a paperless school"*, to which Ms Mbheki added, "… *so it's not really paperless as it's going, but I think it is a dream that is eventually possible, but for now, too many factors against it"*. The reality of a paperless classroom still appears to be a figment of the MEC's imagination and the timeline that he set for the implementation of a paperless classroom is unrealistic. The above information provided by the participants indicates that the situation in the Mathematics classrooms is contrary to the Gauteng MEC's anticipated paperless classrooms. From the excerpts in this section, it is obvious that the traditional method of teaching and learning continues to dominate the Mathematics classrooms in the identified cases. The smartboards are not being used to their optimum but have become a substitute for the traditional chalkboard or whiteboard.

Ms Sedibe from Isilomo Secondary School agreed with the above comments when she pointed out that the use of exercise books remains a necessity in the classroom:

> *… we still use the exercise books, we also use the tablets… the reason why we still use the … exercise books, is because at times eh, you find that there is no electricity and the batteries will be flat, so we cannot do away with the exercise books, we cannot say today there won't be any learning because there is no electricity.*

The lack of electricity is an infrastructural problem that inhibits the implementation of technology in teaching and learning and more so in a paperless context. In South Africa, load-shedding[6] is a reality where the supply of electricity to selected areas is "shut off" for a specified number of hours in a day to prevent a blackout. If an area experiences load-shedding, teaching and learning is automatically negatively impacted in a paperless environment. However, if the chalkboards or whiteboards were to remain fixed to the walls in the classrooms, teaching and learning would continue despite the absence of electricity. Once again, the challenge of load-shedding provides evidence that a blended teaching and learning environment would be more suitable and appropriate under these circumstances. A learner added, "... w*e [are] blended because sometime[s] you can find there's load-shedding like there's no electricity, so whenever there's like no electricity, the smartboard is not working so we use textbooks[hardcopies]"*. There was consensus amongst most of the participants, both teachers and learners, that the uncertainty of whether there would be electricity available or not, was seen as a major constraint to teaching and learning in a paperless environment.

Mr Bhengu, from Intaba Secondary School, provided additional evidence that exercise books are used consistently in his Mathematics classes *"I use eh my tablet for textbooks and other resources, but the learners use their books, exercise books for their workbooks, ok for classwork and other exercises"*, which is confirmed by Mr Thoko from the same school when he said, "*... for now, we are not 100% paperless*". To make the point again, the above excerpts indicate that teaching and learning at this particular site takes place in a blended environment. Technology is used mainly to access the textbook and other electronic resources; however, all Mathematical activities are completed in exercise books, as was evident in the other three cases. The fact that teaching and learning were not conducted in a paperless environment was verified during the observations of the Mathematics lessons at this site. None of them had access to a smartboard in their classrooms, although the smartboard software had been loaded on their tablets and laptops. Teachers used a data projector to project the material prepared for the lesson on a whiteboard, which eventually left them with no whiteboard to write on or explain concepts that required further clarification to learners.

[6] "Load shedding is a measure of last resort to prevent the collapse of the power system country-wide. When there is insufficient power station capacity to supply the demand (load) from all the customers, the electricity system becomes unbalanced, which can cause it to trip out country-wide (a blackout), and which could take days to restore. When power is insufficient, Eskom can thus either increase supply or reduce demand to bring the system back into balance" (http://www.eskom.co.za/documents/LoadSheddingFAQ.pdf)

Mr Museba despite being well versed with the use of technology acknowledged:

> *… personally, in my lessons, I'm not paperless as it were. I combine both technology and old school where I'm using the smartboard markers here. So, if I use technology it's basically projecting what images I maybe downloaded online or work, stuff that I personally typed on my laptop, ja. Ja, for me I'm saying that there are certain things that develop during the lesson, there are certain concepts that develop during the lesson that would want me to illustrate using the old school method. At the moment, the technology that I am experienced to, will not allow me to use it on concepts that just crop up, like your learners that ask questions that asks clarity seeking questions that want you to explain. I have no backup technology to use to explain, so I resort to the old school method.*

Although a paperless classroom is a good concept, it does not lend itself to the practical classroom situation as described above by Mr Museba. He pointed out that the use of the chalkboard/whiteboard in his classroom is a necessity as at times he requires it to explain Mathematical concepts in more detail to learners, which cannot be achieved using only technology. The description provided by Mr Museba highlights how the traditional method of teaching and learning may be complemented using technology and vice versa. This is an important point that he made, which contrasts with what the Gauteng MEC had in mind regarding paperless classrooms. According to the TPACK framework, it is evident that Mr Museba has the requisite content knowledge, as he is aware that when clarity is sought by learners on specific Mathematical content, he preferred to use the traditional method to explain those concepts because of his limited technological knowledge and experience. As Koehler and Mishra (2009) state, technology knowledge (TK) refers to the various thought processes and recognition of when technology may support or hinder the attainment of an objective, which is precisely the skills that Mr Museba displayed when he chose to use the traditional method instead of using technology, due to his limited technological skills. Mr Mdluli from the same school, pointed out

> *… so now again Mathematics, with the caliber of learners we have in our school, you really have to explain to them. So, now just to give them something to do on their own there, it was a big challenge. So, at the end of the day, we are still using the board to teach them.*

What may be interpreted from Mr Mdluli's statement is that because the learners in his Mathematics class lacked Mathematical knowledge and skills, it was challenging for them to work independently using their tablets, and therefore he resorted to using the whiteboard. The next excerpt by Mr Mdluli confirms the interpretation above and his endorsement of a blended environment:

> *It depends on the type of learners that a school has, it depends. So as I said in a setup like ours where you are teaching learners maybe with 3% in Maths and you go to another school where when they enroll learners those learners that are up there, those two things I think the paperless will totally work in those schools, 100%. But with these other schools, we need blended, maybe it will take time, but we need a blended one, yes.*

It is apparent from the above excerpt that Mr Mdluli is aware of the caliber of learners in his classroom and has the pedagogical knowledge to identify whether technology will enhance teaching and learning or not. An aspect of TPACK is pedagogical knowledge (PK), which states that a teacher's sound knowledge regarding the teaching and learning methods, how learners learn, including lesson planning and assessment is imperative (Koehler & Mishra, 2009). The MEC's statement on paperless classrooms was prescriptive, consequently, not allowing the teacher the freedom to choose the pedagogy that would cater to the diverse abilities of learners. Mr Mdluli is knowledgeable about his learners' Mathematical capabilities and therefore, prefers to teach in a blended environment. From Mr Mdluli's statement above, it is apparent that the learners' Mathematical ability plays a significant role on whether the teaching of Mathematics in a paperless environment is viable or not. Ms Madi voiced her opinion:

> *… we are still using the old system because we are still using papers because we are making copies for learners, it's not paperless… we don't have Maths in their gadgets [tablets]… we need to make copies each and every time… we don't have the assessment which are on the tablets. Yes, all the assessments are still paper, are still on papers. We need to make copies, each and every time if you want to do the SBAs everything. We need to make copies of those activities.*

What is evident from the above excerpt is that assessments have to be conducted on paper as this is a requirement of the GDE. There appears to be an inconsistency between the MEC's expectations of teaching and learning in a paperless context and the requirements of the GDE. Once again this presents a key issue that teachers are confronted with when attempting to implement a paperless environment as there is an apparent contradiction between the MEC's dictum on paperless classrooms and the GDE requirements regarding assessments, which are paper-based. Ms Smit added *"… the biggest problem we have is our learners still need to keep our writing function in schools because the Matrics still write their exams [on paper]"*. The issue regarding assessments being conducted using pen and paper was evident at Isilomo Secondary School where I observed Mathematics teachers sitting in the staff room collating question papers for a Mathematics assessment. All participants confirmed that assessments are currently conducted using paper, specifically because of the requirements of the GDE officials,

who on inspection request hardcopies of learners' assessments as well as printed copies of the marks that learners attained.

Ms Madi pointed out that the smartboard in her classroom had not been working for a considerable length of time, thus contributing to her inability to teach using this device. When I requested to observe her lesson using technology, she had to arrange to use another teacher's classroom where the smartboard was working. Once again like the other teachers, Ms Madi substituted the smartboard for a chalkboard/whiteboard and did not incorporate technology optimally. Mr Thuli from the Harry Gwala Centre, situated on the school premises, confirmed that many of the smartboards at this site were not working. If teachers were to teach in a paperless environment it would require all technology to work at its optimum, which would then be an ideal situation, however, this was far from reality. From the data collected in this study, it is evident that all the cases are not close to operating in an ideal situation. Mr Namane summed up the situation of teaching and learning at his school as follows *"... it's 40% paperless at the moment"*. Consequently, it was important for me to investigate participants' preferences regarding teaching and learning in a paperless environment in comparison with a blended environment. Table 5.5 below represents extracts from both teachers' interviews and focus group discussions with learners indicating their preference concerning the learning environment for Mathematics, followed by a discussion on their preference.

Table 5.5 Teachers' and Learners' Preference for the Learning Environment

Representative phrases from participants	Open coding	Axial coding
"I would definitely prefer it to teach in a blended environment, eh the reason being as I told you in our school, we are enrolling mixed ability groups. There are learners who come in here eh with a Maths background which is almost zero, yes. So, to say to those learners we are doing things on a tablet, it comes with its own disturbances… the way I see it, even the blended it will take more of the old system and the less percentage of the new system" (Mr Mdluli). "I prefer using both smartboards and paper… I don't prefer paperless environment" (Mr Khoza). "I would choose a blended environment… I think this stage that we are in a blended environment would be the most perfect one because our learners are still used to… papers… as educators, we are still having that background of using textbooks and papers… Considering that our learners are still writing exams … on papers… I would prefer a blended environment" (Ms Bhengu). "I don't agree…that we should learn Maths without papers… when I write Maths, I have to write examples, so where am I	Preference/blended environment. Learners/mixed abilities. Teachers/educational background. Paper-based assessments.	

going to write them? I use a paper and a pen to write. Yes, we can use technology and our papers to write examples… I understand when I write down. So, I cannot understand when I just see something only without writing down" (learner). "… definitely, blended because like I said, you have your different learners… some learners will learn easily by seeing pictures or videos and they will grasp it quickly, others learn differently" (Ms Smit). "Yes, where you use the traditional teaching supported, we integrate the technology method" (Ms Madi). "I always prefer that learners write, and they do something practical, it's a bit of a problem because I don't think it [Mathematics] can entirely be taught in a paperless classroom" (Mr Nkosi). "The writing will still be there, it is better if we use both, but concentrate more on technology" (Mr Sangu).		
"… because with Maths… we use it minimally because we need to show them the sums you know they need to be with you when you work out the sum so that they can actually… learn the methods... So, I really, personally I won't go to it, unless when… I refer to their textbook" (Mr Dlamini). "… so, if I had a choice personally, I will say they must not use them [technology] during Maths periods and then if there's a need… like I said GeoGebra can show you some of these things, now just to illustrate a little" (Mr Dlamini).	Minimal use of technology. Tablet used to reference the textbook only.	
"I feel like it's better if we learn Mathematics on paper" (learner). "I feel like sticking to paper is easier because some of us understand by writing things" (learner). "I feel like most people, not everyone but like most people learn better when they write stuff" (learner). "It is easier to recognise your mistakes when you write it down on paper" (learner). "… learning Maths from a device, it just doesn't work because for me to memorise all the formula and everything that the teacher teaches, I need to write them down to get them in my head" (learner). "Maths you have to practice, to get it, you can't just repeat it out loud… I feel like learning Maths from a device it doesn't work for me" (learner). "Sometimes I do struggle using technology and I really prefer the old method… using technology I don't understand" (learner).	Learner preference/paper-based/writing on paper. Understand Mathematics/writing on paper. Easier to recognise mistakes on paper. Learner technological skills. Mathematics need practice on paper/writing.	
"I feel Maths is a subject that solely needs to remain on paper and so needs to be written down" (learner). "Tablets is very disturbing… I can't concentrate on my work, so I don't like the idea of using technology" (learner). "Movies… different games, you know, so it would be very hard for me to study" (learner). "I cannot have a tablet you know and do not put my personal things in there and use it for education only… So that is why I feel like I should not have it" (learner). "I think I'd prefer a more of a paper… environment because even if you look at stats there was, the pass rate was higher	Mathematics/solely on paper. Tablets/distraction. Inappropriate use of tablets. Learners' choice. Learners' results.	

when there was paper… it was way higher than how it is right now. There's too many distractions with the tablets, that's why" (learner).		
"I personally think that it shouldn't be… introduced into schools, that we should be in paperless classrooms cos I don't think it would work out. Technology, I can't practice using technology, so it's more like I will be reading Maths, not practicing Maths" (learner).	Learner/paperless classroom will not work	
"I prefer learning in a blended environment because then in my earlier grades, in Grade 8 and 9 we used to write like tests on our tablets and once you put in the answer, there is no going back … when it's on paper I can actually scratch it out and fix my mistake whereas if I just put it in, on my tablet it's there and it affects my results at the end of the day" (learner). "I feel like I would rather learn in a blended environment because paperless sometimes like we are doing activities or having tests, you have those moments where you have to memorise the night before and then, you have to memorise exactly as the computer wants it, it's not your own answer so and sometimes people will take time to memorise and do all that and they expect us to be like computers which we are not" (learner).	Learner preference/blended. Assessment/paper-based. Flexibility/cannot correct answers using technology.	
"… if you have to put in the answer it has to be word for word and sometimes that just doesn't work because you want to change the answer to make it into your own words so you can actually show that you understood what was being taught" (learner). "I found that the questions were not as stimulating … as they were… very easy …, they were straight forward questions. The multiple-choice questions would be something that was very straight forward compared to when you had paper… the questions …, the way they would ask them they would be more challenging" (learner).	Constraints of assessments using technology.	
"I prefer blended because with the paperless I feel like when we are writing exams, students will always find a way to cheat" (learner).	Technology/cheating.	
"… loss of tablets and the stealing internally from the school, learners stealing tablets from each other internally from the school and two, parents themselves telling learners to lie that the tablets is lost" (Mr Namane).	Technology theft. Loss of tablets. Parents lie.	
"It would be a challenge… because learners sometimes… they must learn to write because… universities they also use paper… so we must teach them things that will help them in future, ... they still gonna use papers in varsities. So that's why I think both technology and paper environment is needed, it is required" (Mr Khoza).	Higher Education/writing still necessary.	
"… with me eh the old traditional is fine where they do the answering in the exercise book, so that I … will be able to see what are the mistakes that they [learners] are doing" (Mr Maphosa).	Teacher/easy to correct learners' mistakes on paper.	

"… they still have chalkboards ma'am and you find that the smartboard is still working but they prefer … the old method" (Mr Thuli).	Teacher preference/chalkboard.	
"… so sometimes we manage but as for the problem comes when you have to explain something to the learners then if it is not working very well then we have to resort to a whiteboard" (Mr Nkosi).	Challenge/technology not working.	Teachers' and learners' preference for the learning environment: Both teachers and learners preferred a blended environment for Mathematics.
"… the results are very bad with the use of technology. Since technology was introduced, ah learners they don't study at all… in class they don't concentrate" (Mr Khoza). "… when I was teaching Maths using eh the old method eh, I produced quite a number of distinctions and some level 6 … but if we look at our last year's results we only had 1 distinction, yes and the quality actually eh dropped. What improved was the percentage but the quality of the results, I'm sorry to say it dropped … last year the pass rate increased to 97% but then the quality of the results have dropped drastically" (Mr Mdluli). "… so really, they perform dismally, they perform dismally" (Mr Dlamini).	Technology/learners' results negatively affected. Technology/distraction.	
"… we had problems complaints from parents now because the marks for learners were now going down" (Mr Mdluli).	Parents complaints.	

"I would definitely prefer it, to teach in a blended environment"

There was consensus among all teachers that a blended environment is their preferred choice for the teaching and learning of Mathematics. Various reasons were advanced for the choice of a blended environment. According to Mr Mdluli:

> *I would definitely prefer it to teach in a blended environment, eh the reason being as I told you in our school, we are enrolling mixed ability groups. There are learners who come in here eh with a Maths background which is almost zero, yes. So, to say to those learners we are doing things on a tablet, it comes with its own disturbances… because sometimes you are teaching in a class and the learners are doing their own things there… the way I see it, even the blended it will take more of the old system and the less percentage of the new system.*

Mr Mdluli's insights mentioned above, are an opposing view to that held by the Gauteng MEC as he points out that despite using technology, teachers will tend to revert to the traditional methods of teaching and learning, when necessary. As he pointed out, he preferred a blended learning environment to teach Mathematics due to the "mixed ability" of learners in his classroom. He does not exclude the use of technology in teaching and learning; however, it is obvious that he takes note of learners' diverse learning abilities and therefore, finds that a blended environment would be more suitable. As stated earlier in this chapter, a teacher's PK would inform teachers' choice whether to incorporate technology in the teaching and learning

of Mathematics or not, which is at the heart of Mr Mdluli's choice to teach in a blended environment. Perhaps one of the reasons why teachers prefer the blended method of teaching is that not all subject content lends itself to the use of technology as discussed in the literature review in Chapter Three. This is evident in the following excerpt from Mr Dlamini:

> *… because with Maths I'm not sure about other teachers, we use it minimally because we need to show them the sums, you know. They need to be with you when you work out the sum so that they can… learn the methods and stuff, you know. So, I really, personally, I won't go to it, unless when… I refer to their textbook… So if I had a choice personally, I will say they must not use them [technology] during Maths periods and then if there's a need really like, to show them [learners]… what they can do, like I said GeoGebra can show you some of these things, now just to illustrate a little.*

Mr Khoza also endorses the blended environment as his preferred choice:

> *I prefer using both smartboards and paper, paper environment, so using technology and paper so that it can balance. For me the learners that we are teaching, eish, we are getting challenged in terms of eh, teaching Maths. So, by not using the papers, eish, that will be a very big challenge due to teaching because the learners, we've got learners who believe in seeing things, some others they … are good when they are being taught by videos. I, for me I don't prefer a paperless environment.*

Despite Mr Mdluli teaching in a private school and Mr Khoza teaching in a public school, they both cite the same reason for their preference of a blended context, which is the diverse Mathematical abilities of their learners. The final sentence in the above excerpt is significant as it is quite clear that Mr Khoza indicates his aversion to teaching and learning Mathematics in a paperless environment and prefers a blended one. In addition, Mr Khoza provides a reason for his antipathy to a paperless classroom "*So you must avoid allowing them to always depend on technology… so I prefer them to always write"*. Most of the learners from the focus group discussions also voiced their preference for a blended environment, consequently, elucidating the necessity for the exercise books to be used during teaching and learning as is evident from the comments below:

> *I feel like it's better if we learn Mathematics on paper.*

> *I feel like uhm sticking to paper is easier because some of us understand by writing things and we can grasp a lot of things.*

> *I feel like most people, not everyone but like most people learn better when they write stuff because when you writing you understanding and you trying to see if you can actually do something whereas if you are typing it on the IPad or be it a computer you just, you just, it's basically like copying in a way.*

> *… it is easier to recognise your mistakes when you write it down on paper cos [because] then if you press the delete button it's gone and you don't see where you went wrong… whereas on paper you can see where you went wrong here and try to fix that problem.*

> *I feel like using tablets in Maths is not a good option for me because like I said before I like writing things like I prefer seeing my mistakes and fixing it.*

I just really feel that learning Maths from a device, it just doesn't work because for me to memorise all the formula and everything that the teacher teaches I need to write them down to get them in my head.

… we all know that Maths you have to practice to get it, you can't just repeat it out loud. No, you need to practice it and apply it in a sum that is brought out to you. So, I feel like learning Maths from a device it doesn't work for me.

Sometimes I do struggle using technology and I really prefer the old method because I understand something, sometimes… using technology I don't understand… with Maths I feel Maths is a subject that solely needs to remain paper and so needs to be written down.

I don't agree with that thing… that we should learn Maths without papers… when I write Maths I have to write examples, so where am I going to write them? I use a paper and a pen to write, yes, we can use technology and our papers to write examples… I understand when I write down. So, I cannot understand when I just see something only without writing down.

The above statements from the focus groups held at the various sites provide evidence that many of the learners prefer to learn in a blended environment and to retain the use of paper in the Mathematics classroom. Some of the reasons advanced for learners' preference for a blended environment are as follows:

Tablets is very disturbing, like you know I can't concentrate on my work, so I don't like the idea of using technology.

You know, obviously, I cannot have a tablet you know and do not put my personal things in there and use it for education only, you know. So that is why I feel like I should not have it.

Movies ja, different games, you know, so it would be very hard for me to study.

I think this thing of technology should stop cos other learners prefer to write down and you know a hardcopy textbook to learn for. It gives all the information you need all the things you want to know.

I personally think that it shouldn't be … introduced into schools, that we should be in paperless classrooms cos I don't think it would work out. Technology, I can't practice using technology, so it's more like I will be reading Maths, not practicing Maths.

I think I'd prefer a more of a paper… environment because even if you look at stats… the pass rate was higher when there was paper… it was way higher than how it is right now. There's too many distractions with the tablets, that's why.

This is in direct opposition to the MEC's vision of paperless schools, where he stated the elimination of the use of exercise books in the classroom. Earlier in this chapter, Mr Sangu asked a pertinent question regarding if any research had been conducted with teachers before the MEC decided to establish paperless schools. Similarly, considering that learners are the recipients of education, and of teaching and learning, it would have been obligatory to include both parents and learners in the decision to go paperless.

Ms Smit, although not a Mathematics teacher, but who is referred to as the "ICT champion" at her school stated her preference *"... definitely blended because like I said, you have your different learners that learning, some learners will learn easily by seeing pictures or videos and they will grasp it quickly, others learn differently"*. This statement coincides with Mr Nkosi and Mr Mdluli, who also cited learners' abilities, as one of their reasons for a blended environment that teachers need to note. There is an underlying assumption that because learners today are referred to as "digital natives" (see discussion in Chapter Three), they would automatically prefer to be taught and to learn using digital technologies. However, the excerpts below from learners at Intaba Secondary School provide evidence contrary to this erroneous belief:

> *I don't want to be involved in technology and lose the natural way of doing stuff because it makes me lazier when I use technology instead of just doing it manually.*
>
> *I prefer learning in a blended environment because then in my earlier grades, in Grade 8 and 9 we used to write like tests on our tablets and once you put in the answer there is no going back ... when it's on paper I can actually scratch it out and fix my mistake whereas if I just put it in on my tablet it's there and it affects my results at the end of the day.*
>
> *I feel like I would rather learn in a blended environment because paperless sometimes like we are doing activities or having tests, you have those moments where you have to memorise the night before and then, you have to memorise exactly as the computer wants it, it's not your own answer so and sometimes people will take time to memorise and do all that and they expect us to be like computers which we are not.*
>
> *... if you have to put in the answer it has to be word for word and sometimes that just doesn't work because you want to change the answer to make it into your own words so you can actually show that you understood what was being taught and then also I prefer blended because with the paperless I feel like when we are writing exams, students will always find a way to cheat not that in a blended they don't cheat, they do cheat and we catch them but in a paperless, I feel like it would be a little bit harder to catch them.*

Learners' preference for a blended environment is attributed to their experiences regarding assessments using technology. It is apparent from the 2nd excerpt, that a learner was unable to correct answers that were submitted in a technology-based assessment, possibly because the assessment prohibited backtracking; however, they pointed out that this was possible with the use of pen and paper. In addition, learners stated that in a traditional paper-based assessment they are encouraged to demonstrate their understanding by answering in their own words, whereas the use of technology required them to provide answers that matched the stored answer to the question. They believed that this type of assessment disadvantaged them and affected their results negatively. Another learner asserted:

> *I found that the questions were not as stimulating … as they were… very easy …, they were straight forward questions, the multiple-choice questions would be something that was very straight forward compared to when you had paper… the questions …, the way they would ask them they would be more challenging.*

One of the concerns, as mentioned by the above learner, was that the questions in the assessment were extremely easy as they were multiple-choice questions. This indicates that the assessment comprised level 1 questions (remembering) according to Bloom's Taxonomy and did not assess the higher-order thinking skills of learners. For Mathematics, this type of questioning is not suitable. Additionally, Mr Namane pointed out that the "… *loss of tablets and the stealing internally from the school, learners stealing tablets from each other internally from the school and two, parents themselves telling learners to lie that the tablets is lost"*, was another challenge. What is disturbing is that learners are stealing tablets from one another and parents are encouraging them to lie. If Mathematics was taught in a "truly" paperless environment, this would have serious implications for teaching and learning, thus making it non-viable for teaching and learning to take place in a paperless context. However, in a blended environment, teaching and learning can continue without the use of technology.

Mr Bhengu acquiesced with the other teachers regarding his preference for a blended environment:

> *I would choose a blended environment… like I said it, we need to allow the transition period between from the traditional way into paperless. So, at this stage ne, I think this stage that we are in a blended environment would be the most perfect one because our learners are still used to paper, using papers so and us also as educators we are still having that background of using textbooks and papers. So, and also considering that our learners are still writing exams in, they are writing on papers and everything, eh, that's why I would prefer a blended environment. Maybe 100% paperless later, maybe after, maybe after 100 years, 20 years or something. But for now, at this stage, I think blended will be fine.*

At the Grade 12 level, learners write their examinations on paper. If learners are taught and assessed in a paperless environment, the skills required to be assessed using paper-based assessments in Grade 12 would be lacking. Consequently, a blended environment would be most appropriate since learners would have acquired the skills to use both paper as well as technology for assessment purposes thereby not placing them at a disadvantage for their final assessment in Grade 12. It is important to note Mr Bhengu's opinion that paperless classrooms should have been introduced gradually as learners and teachers are accustomed to the use of pen and paper. There is an alignment between Mr Bhengu and Mr Namane's thoughts on

paperless classrooms as both these teachers envision paperless classrooms as something in the future.

Mr Khoza goes a step further when he refers to Higher Education:

> *… it would be a challenge because learners sometimes they must, they must learn to write because especially in varsities, like universities they also use paper, they also use papers, they write tests, they write exams using the papers. So, we must teach them things that will help them in future, ... they still gonna use papers in varsities. So that's why I think both technology and paper environment is needed, it is required*.

It is important to take note of Mr Khoza's statement because as a University lecturer I can attest to this fact that the majority of the assessments are conducted using pen and paper and writing skills are a necessity. A very noteworthy point made by all teachers at the four sites, is that assessments at their schools are still conducted using pen and paper despite being identified as paperless schools. What could be inferred from Mr Bhengu's statement when he says "… *maybe a 100% paperless later, maybe after, maybe after 100 years, 20 years or something"* is that a paperless classroom may not be viable.

Ms Baloyi cited an example of where learners can be taught to draw a graph, for example, Sin x using the traditional method and then using technology one can show the movement of the graph if it changes to Sin x + 30 or Sin x – 30. According to her, the learners in her class got excited when they saw this movement of the graph using technology. What the teacher was concerned about was that learners would be more impressed with the visual effect of the graph moving and would not have grasped the actual Mathematical concept. This is where she felt strongly that learners must first be taught mathematical concepts using pen and paper and then the same concept could be demonstrated using technology as reinforcement. Like the other participants in this study, Ms Baloyi favours a blended teaching and learning environment for Mathematics. In her opinion, learners must practice on paper to fully grasp the Mathematical concepts being taught. Ms Madi agreed with Ms Baloyi as is evident from the following excerpt;

> *So, when I teach that topic [Geometry] I prefer to use the old system that I use my own compass, ruler, etc. so that the learners can understand easily. I think I will prefer both methods, both systems I think but I, we can use the one of using chalkboards or the papers and everything and maybe integrate technology where you want to emphasise some of the, maybe the concepts or things that they don't understand in Mathematics. Yes, where you use the traditional teaching supported, we integrate the technology method*.

As discussed in the literature review in Chapter Three, some South African universities require Grade 12 learners to write the National Bench Marking Tests (NBTs) to be considered for specific qualifications. The Mathematics component of the NBTs prohibits the use of a calculator. If learners were taught in a paperless environment, where calculations were done using the calculator, then these learners would be placed at a disadvantage and consequently, may perform poorly.

To highlight the importance of pen and paper in a so-called paperless classroom, Mr Maphosa emphasised that exercise books are still a necessity and, in his opinion, important:

> *I don't think it's [paperless classroom] possible, with me eh the old traditional is fine where they do the answering in the exercise book. So that I can be, will be able to see what are the mistakes that they [learners] are doing. When you do the marking that is when you can see the challenges the learners have and be able to rectify whatever mistakes.*

Mr Nkosi concurred with Mr Maphosa

> *I always prefer that learners write, and they do something practical, it's a bit of a problem because I don't think it [Mathematics] can entirely be taught in a paperless classroom, in a sense that learners should do something practical. Maths from what I know, is Maths, is a skill which needs practice and practice to me. So, I don't know how they will entirely do away with the paper, but to me, we still do need eh, a book a pen.*

It is necessary to point out that Mr Nkosi is a qualified Mathematics teacher who has been teaching the subject for a considerable number of years; he has the experience and knowledge to make an informed decision about the viability of a paperless classroom. He firmly believed that Mathematics cannot be taught in a paperless environment, and if teachers believe that Mathematics cannot be taught solely with the use of technology, then it is implied that a paperless classroom is not viable. Teacher preference regarding the use of technology is an important component that questions the viability of teaching and learning in a paperless environment. Mr Thuli, a technician from the Harry Gwala Centre claims *"... they still have chalkboards ma'am and you find that the smartboard is still working but they prefer no, no, no I don't want this technology, I prefer the old method"*. What Mr Thuli has mentioned is significant because for teaching and learning in a paperless environment to be viable and sustainable, it is the teachers who could make this a reality. If teachers are not confident that teaching and learning can take place solely with the use of technology, or they lack the self-efficacy beliefs to integrate technology in their disciplines, then this will present a challenge to the existence of "truly" paperless classrooms.

Although Mr Sangu's classroom was fitted with a smartboard, he indicated that he would have preferred both a smartboard and a whiteboard as is evident from his statement "*I said 'ok, my solution is you put the smartboard and leave the space for a whiteboard so that I can use both' because I, sometimes you need to concentrate on the smartboard but you need to give some notes where are you going to give those notes?*" He added, "*The writing will still be there, it is better if we use both, but concentrate more on technology*". Mr Sangu's statement denotes his preference for both the smartboard and the whiteboard because he indicated that if a teacher is using the smartboard to display for example the textbook, then it is not possible for him to write on the same smartboard. He feels it is necessary to have a whiteboard alongside the smartboard to enable him to accomplish both writing and projection of any topic being taught. Mr Namane concurred *"If you are explaining something on the smartboard, you need to write it on the whiteboard, let's drill the whiteboards on these walls so that we have a whiteboard and a smartboard, but they must work together not in isolation*". To re-emphasise, Mr Namane is the ICT committee member at Iziphethu Secondary School, who is responsible for driving the ICT initiative, yet he firmly believed that the installation of smartboards in the classrooms should not imply that one needs to remove the whiteboard or the chalkboard as indicated in his statement:

> *One shouldn't replace the other but that's not how it's viewed. It is viewed as one should replace the other and … that's where the problem is."* In addition, Mr Nkosi shared his view *"… so sometimes we manage but as for the problem comes when you have to explain something to the learners then if it is not working very well then we have to resort to a whiteboard.*

There was consensus among all the participants that the whiteboard should remain a fixture in their classrooms alongside the smartboards as teachers still required the use of the chalkboard/whiteboard at times. This reluctance by teachers to part ways with the chalkboard/whiteboard is significant, giving credence to the fact that teaching contexts (traditional, blended, paperless) should not replace one for the other, instead, they could be combined to add value or enhance the teaching and learning process and possibly improve learners' academic performance.

Despite the benefits of integrating technology in teaching and learning, learners' results in Mathematics were adversely affected in Mr Khoza's opinion *"… the results are very bad… the results are very bad… the results are very bad with the use of technology. Since technology was introduced, ah learners they don't study at all… in class they don't concentrate*". Mr

Dlamini, a colleague of Mr Khoza agreed "*... so really they perform dismally, they perform dismally"*. Mr Mdluli, who is from another site, added, "*... we had problems, complaints from parents now because the marks for learners were now going down*". What may be inferred from the above statements is that because learners use the tablets for other purposes other than education, learners' results in Mathematics have worsened. Mr Mdluli in the excerpt below stated that when he used the traditional method of teaching and learning, his learners performed much better compared to when using technology:

> *... when I was teaching Maths using eh the old method eh I produced quite a number of distinctions and some level 6. There were so many of them but if we look at our last year's results, we only had 1 distinction, yes and the quality actually eh dropped. What improved was the percentage but the quality of the results, I'm sorry to say it dropped ... last year the pass rate increased to 97% but then the quality of the results have dropped drastically.*

The observation by Mr Mdluli is significant because the intention of integrating technology in teaching and learning is to improve learners' academic performance. However, if individual learners perform worse than they did without the use of technology even though they passed the subject, then the use of technology was not effective.

Summary

The Gauteng MEC's statement to the press regarding paperless schools is central to this study as in his statement he explicitly stated that all teaching and learning in these so-called paperless schools, would be conducted without the use of pen, paper, exercise books as well as the chalkboard/whiteboard. It was, therefore, important to elicit both the teachers' and learners' opinions regarding the expectations of the MEC. From the findings, it is evident that all participants believed that teaching and learning Mathematics in a paperless context was not viable and provided various reasons why. It was important to determine whether the Mathematics teachers in this study had a clear understanding of what a paperless classroom, entails. Most of the teachers understood that a paperless context meant teaching and learning solely with the use of technology as emulated by the Gauteng MEC, while a few teachers interpreted a paperless context as the reduction of paper usage in education. For the paperless initiative to be accomplished, all stakeholders must be aware of what the process entails as the provision of information as required by the district officials, would differ when compared to other schools that are not designated as paperless. The discussion in this chapter revealed that currently, no such alignment exists between the DoE and the district offices.

It is important to point out that none of the Mathematics teachers in this study were averse to the use of technology in the teaching and learning of Mathematics but pointed out that they preferred to teach in a blended environment because of the various challenges they experienced. Similarly, learners pointed out:

> *No, it's, it's better the way it is now as blended instead of paperless.*

> *I really feel that the blended environment is much better because in that way we have both situations and no-one is actually left out and then you get the more people that preferred technology, they work in their comfort zone so, I'm comfortable with my technology and therefore I know how to work around my technology. Therefore, I do more and the people that prefer the paper they are in their comfort zone and they do more and in that sense, the school also gets better results because everyone is comfortable, and everyone is working.*

Cognisance should be taken of the needs of learners as indicated by a learner in the following extract:

> *The problem that we are experiencing is that learners complain about the tablets restarting on their own and we have textbooks in our tablets that we use for each and every lesson. So if your tablet has restarted then there's no textbooks, you have to ask another learner for a screenshot and it's going to take a long process so I think the use of paper and tablets correspond with each other very well, so we need both, not one or the other.*

Mr Dlamini endorsed the above statement when he said "*I think it's more like they need to complement each other if to actually work"* because as indicated by a learner "…*with education it's not about how fast we learn or whatever, it's how well we learn*".

The next chapter presents Part 2 of the discussion of the findings, which are the challenges experienced by both teachers and learners regarding the use of ICTs in Mathematics lessons.

CHAPTER SIX

FINDINGS AND DISCUSSION

PART 2: CHALLENGES REGARDING THE INTEGRATION OF ICTS IN THE TEACHING AND LEARNING OF MATHEMATICS

Introduction

Teachers and learners at these so-called paperless schools have faced numerous challenges regarding the integration of ICTs in the teaching and learning of Mathematics. This chapter provides a discussion on the challenges experienced at the four selected cases in this study. After the thematic analysis of the raw data, the main theme that emerged was challenges and the sub-themes that appear in the diagram below.

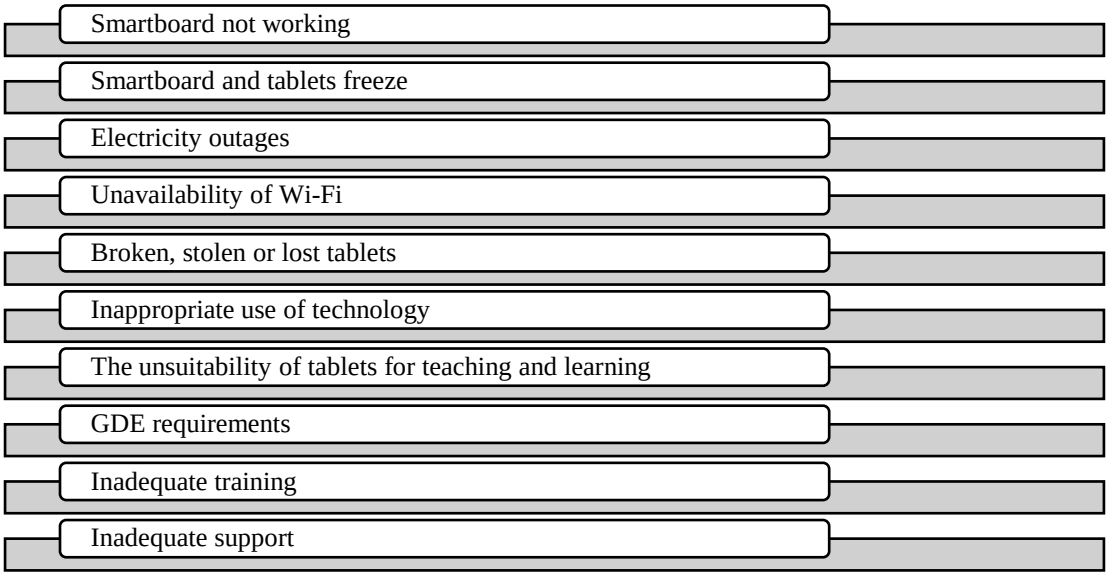

Figure 6.1 Sub-themes for Challenges

The sub-heading for each elicited theme is represented by the exact words from either the interviews with Mathematics teachers or focus group discussions conducted with Mathematics learners. The table below provides a summary of the open codes and the axial code extracted during the analysis of the data, followed by a discussion on the sub-theme "smartboard not working" that emerged.

Table 6.1 Smartboard not Working

Representative phrases from participants	Open coding	Axial coding
"Even now lots of classes the smartboard doesn't work" (Ms Madi). "I use the chalkboard during the lesson because now I cannot … [lose] eh time waiting for the technician to come and fix the smartboard because now if the smartboard is not working, I need to teach. So now obvious I need to use the old system of using the chalk and the duster" (Ms Madi). "Even right now as you can check, all my Grade 11 classes the smartboards are not operating" (Mr Thuli).	Smartboard/not working. Traditional method of teaching.	Smartboard not working: the smartboard not working was a challenge at one of the sites.

"Even now lots of classes the smartboard doesn't work"

The above statement identifies the situation at Iziphethu Secondary School, as conveyed by Ms Madi, who had to make use of another teacher's classroom when requested to have her Mathematics lesson observed, as the smartboard in her classroom was not working. When asked what happens to teaching and learning if the smartboard was not working, she added:

> *I use the chalkboard during the lesson because now I cannot … [lose] eh time waiting for the technician to come and fix the smartboard because now if the smartboard is not working, I need to teach. So now obvious I need to use the old system of using the chalk and the duster.*

Despite having borrowed another teacher's classroom for the observation, Ms Madi did not use the smartboard for the manner it was meant, instead she used it as a traditional whiteboard. In Chapter Five, most of the teachers indicated that they preferred to teach Mathematics in a blended environment and provided several reasons for their choice. The above situation as experienced by Ms Madi, as well as her colleagues at this particular site, is an additional reason why the viability of teaching and learning in a paperless environment is questionable. To re-emphasise, teaching and learning should continue whether the technological devices are working or not, as teachers have a curriculum to complete on which learners will be assessed. In addition to the smartboard not working, most of the teachers indicated that the smartboard freezes during lessons. The table below provides a summary of the open codes and the axial code that was derived from both teachers' and learners' excerpts on this sub-theme. A discussion of the sub-theme "smartboard and tablets freeze" is presented after the table.

Table 6.2 Smartboard and Tablets Freeze

Representative phrases from participants	Open coding	Axial coding
"It just gets frozen… that is when now you start stammering" (Ms Madi). "… at times when I'm busy… teaching the smartboard just freezes to the extent that I fail to save some of the work, I'm forced to switch it off and that work will just disappear, and it just happens anytime" (Ms Madi).	Smartboard freezes. Teacher/flustered. Loses work.	Smartboard and tablets freeze: teachers and learners complained that the smartboard as well as the tablet freeze regularly.
"Sometimes we have a problem with the gadgets themselves because it freezes… not… having a knowledge of somehow to solve the problem of the technology" (Mr Nkosi).	Teacher/lack of technological knowledge.	
"What I dislike is that our tablet when you use it for maybe more than two minutes, it starts freezing, what one month is enough, it cracks, its freezes, it's doing whatever, we don't understand, these tablets" (learner).	Tablets/freezing. Tablets/reliability.	
"… one of the things that I'd say is messing up all these things is… we can log a call today telling them [GDE] about fixing things but they gonna take forever ma'am because even right now as you can check, all my Grade 11 classes the smartboards are not operating… so how are they expecting for those learners and educators to perform that side ma'am?" (Mr Thuli)	GDE/lack of support/technology repairs.	
"… sometimes the smartboard doesn't work and now we have to fetch [the] technician and wait for her to get here and fix our smartboard" (learner).	Time wasted.	

"It just gets frozen… that is when now you start stammering"

Most of the teachers complained about the smartboard "freezing" during a lesson, *"… at times when I'm busy… teaching the smartboard just freezes to the extent that I fail to save some of the work, I'm forced to switch it off and that work will just disappear and it just happens anytime*". The smartboard freezing during a lesson disrupts the flow of the already prepared lesson and as indicated above, teachers are compelled to resort to the traditional method of teaching in such instances. From the above sub-heading, it is obvious that such a situation causes the teacher to falter as they did not expect nor have a contingency plan should the smartboard freeze.

Apart from the smartboard freezing, learners' tablets also freeze, as Mr Nkosi pointed out; "*Sometimes we have a problem with the gadgets themselves because it freezes"* and he claims that *"… not … having a knowledge of somehow to solve the problem of the technology*", is an added challenge. Mr Nkosi's statement is confirmed by learners, who experienced the tablets freezing "W*hat I dislike is that our tablet when you use it for maybe more than two minutes, it*

starts freezing, what one month is enough, it cracks, its freezes, it's doing whatever, we don't understand, these tablets". Despite attempting to use technology for teaching and learning, it becomes a challenge when either the smartboard or the tablets freeze because teachers were not trained on how to solve such problems. The smartboard and the tablets are two technological devices that are available for teaching and learning at paperless schools. If both teachers and learners are constantly experiencing problems with technology, *will a paperless environment be viable?* Mr Thuli, a technician at the Harry Gwala Centre at Iziphethu Secondary School indicated:

> *… one of the things that I'd say is messing up all these things is… we can log a call today telling them [GDE] about fixing things but they gonna take forever ma'am because even right now as you can check, all my Grade 11 classes the smartboards are not operating… so how are they expecting for those learners and educators to perform that side ma'am?*

It is apparent from the above excerpt that timeous support from the GDE regarding the repair of the smartboards and tablets is seriously lacking, as a result affecting teaching and learning adversely. Consequently, teachers despite being in a paperless school and required to teach in a paperless environment, resort to teaching and learning in a blended one because of the numerous challenges experienced with the technological devices. In the event of learners' tablets or the smartboards not working, teaching and learning could continue in a blended environment with the use of the chalkboard/whiteboard, hardcopy textbooks as well as pen and paper.

According to Harris (2017, p. 4), there are three key elements to transition from the traditional method of teaching to a blended environment. These are "… *a strong implementation plan by administration, the willingness of classroom teachers to accept the challenge of implementing Blended Learning into their classrooms, and the necessary technology devices and network infrastructure supported by the Technology Department"*. All teachers were amenable to the use of technology in teaching and learning; however, the majority could not see a paperless classroom being viable. This being the case, a blended environment would be more viable as teachers are working in a blended environment.

Harris (2017) referred to the need for the network infrastructure to be supported by an information technology (IT) department. The Harry Gwala Centre, which provides IT support, is found at two of the sites. As stated by Mr Thuli, it is not working as efficiently as he would

expect it to, thus interrupting teaching and learning when executed, whether in a blended or a paperless context. A learner from Illungelo Secondary School added *"... sometimes the smartboard doesn't work and now we have to fetch [the] technician and wait for her to get here and fix our smartboard"*. This disrupts the lesson as time is wasted while waiting for the technician to fix the problem, resulting in the teacher being unable to complete their lesson as planned, consequently, delaying the teacher with regards to completing the curriculum. An additional challenge unique to South Africa, is load-shedding. This interrupts the power supply, which could last for several hours. Excerpts from both teachers and learners can be found in the summary table below that indicates how the sub-theme "Electricity outages" was arrived at, followed by a discussion on this.

Table 6.3 Electricity Outages

Representative phrases from participants	Open coding	Axial coding
"… if there's no electricity everything will be shut down" (Mr Namane). "… you know ICTs sometimes it fails like we had several power failures in the past, you are in the middle of a lesson and it happens… then we don't have a chalkboard… then its school out, that period, immediately schools out" (Mr Dlamini). "… if there is a power outage… like here there is no chalkboard, then I basically can't teach" (Ms Mbheki). "… so, if we say we are going to go 100% paperless it means on other days where there is no electricity, learning won't take place, so we have to cater for learning to be there all the time" (Ms Sedibe).	No teaching. No backup/ chalkboard. No electricity /teaching halted. Paperless classroom/viability?	Electricity outages: participants from all four sites cited electricity outages as a challenge when integrating technology in teaching and learning.
"… at times there won't be electricity and we are forced to use eh, some textbooks [hardcopies] and exercise books" (Ms Sedibe). "While we wait for [the] electricity… we are delayed, we get delayed in our studies" (Ms Sedibe).	Revert to textbooks/exercise books. Loss of teaching time.	
"… when there's power failure for a long time the generator that they are using, only powers certain blocks and that's the challenge. If the whole school can be powered it can make things smoother, if that is sorted it will be ok" (Mr Mbatha).	Generator/not adequate.	
"For example, here in our school, we don't have a generator, as a backup, meaning that if especially if its summer you find that if there is a lightning then the electric is gone. Then it means that day there will be no teaching or learning that will take place at all because you will find that the smartboard will be shut down" (Ms Mashego).	No backup/generator. No electricity/smartboard won't work.	
"… some of the learners are living in eh, shacks where there are no electric" (Ms Mashego). "… will that child write exams or what are we going to do about it?" (Ms Mbheki)	Socio-economic status of learners. Paperless classroom/ viability?	
"I don't use it that much, to become that big of a problem" (Ms Mbheki).	Technology-use/minimal.	

"If there's no electricity everything will be shut down"

The problem of power outages was mentioned as a challenge as most of the teachers cited this as inhibiting teaching and learning when using technology. Mr Namane confirmed that no teaching takes place if there is no power since there is no backup. This statement is supported by Mr Dlamini from Isilomo Secondary School:

> *... you know ICTs sometimes it fails like we had several power failures in the past, you are in the middle of a lesson and it happens… then we don't have a chalkboard… then its school out, that period, immediately schools out.*

Ms Mbheki concurred *"… if there is a power outage… like here there is no chalkboard, then I basically can't teach"*. In addition, Ms Sedibe touched on a significant issue "… s*o if we say we are going to go 100% paperless it means on other days where there is no electricity, learning won't take place, so we have to cater for learning to be there all the time"*. Mr Museba asked, *"What happens if you have planned your lessons for a paperless eh situation and there's no electricity?"*

In a paperless context, the textbooks, notes and exercises are all available on the tablet and smartboard. Without electricity, the smartboards do not work and if there are no backup generators to power these, teaching and learning would come to a "standstill" as indicated by the above comments. However, if there was a chalkboard or a whiteboard available in each classroom, teaching and learning could continue irrespective of whether there was electricity or not. Ms Sedibe indicated *"… at times there won't be electricity and we are forced to use eh, some textbooks [hardcopies] and exercise books"*. Ms Sedibe's contingency plan in the event of electricity outages, is reverting to the traditional method thus not wasting any teaching and learning time. The traditional-based method of teaching and learning is an integral component of a blended environment. Therefore, based on the above discussion, a blended environment would be more viable than a paperless one because as a learner pointed out *"While we wait for [the] electricity… we are delayed, we get delayed in our studies"*. Consequently, the viability of teaching and learning in a paperless environment once again becomes a contentious issue and is one of the reasons why a blended environment would be more suitable and preferred by most of the teachers in this study.

Although Illungelo Secondary School (historically white ex-Model C School in the suburbs) has a generator as a "backup" in case of electricity outages, Mr Mbatha stated:

> *... when there's power failure for a long time the generator that they are using only powers certain blocks and that's the challenge. If the whole school can be powered it can make things smoother, if that is sorted it will be ok.*

This was the only school where a generator was available during power outages. Ms Mashego from Isilomo Secondary school confirmed that her school did not have a generator:

> *For example, here in our school, we don't have a generator, as a backup, meaning that if especially if its summer you find that if there is a lightning then the electric is gone. Then it means that day there will be no teaching or learning that will take place at all because you will find that the smartboard will be shut down.*

The unavailability of electricity at schools may be due to power outages caused by bad weather conditions or load-shedding, however, many learners who live in the informal settlements do not have access to electricity, as pointed out by Ms Mashego "*... some of the learners are living in eh, shacks where there are no electric [electricity]"*. To combat this problem of learners not having access to electricity, a limited number of charging banks have been installed in the classrooms. However, if there is no electricity available at school, these learners will be further disadvantaged as they will not be able to charge their tablets and therefore, will not be able to complete their homework or study. In addition, in a paperless environment, assessment should be conducted on a technological device, in this case, learners' tablets; however, if learners' tablets are not charged, Ms Mbheki asked the following pertinent question "*... will that child write exams or what are we going to do about it?"* Based on the problem of power outages and the smartboard freezing, Ms Mbheki added, *"I don't use it that much, to become that big of a problem*". Considering that this is a paperless school where technology is supposed to be used solely for teaching and learning; Ms Mbheki's teaching strategy is contrary to what is expected in a paperless context. If there is no electricity, then there is no access to Wi-Fi; the majority of the participants in this study claimed that access to Wi-Fi was problematic. A summary of the derived sub-theme "Unavailability of Wi-Fi" is found in the table below, followed by the discussion.

Table 6.4 Unavailability of Wi-Fi

Representative phrases from participants	Open coding	Axial coding
"… for two years we have been off-line in terms of Wi-Fi" (Mr Namane). "… sometimes there will be no network so we can't access the internet or any website, during that particular day if the Wi-Fi is not working so we've got challenges on that bit" (Ms Madi). "… connectivity is affecting us a lot. Ja, so sometimes you have to come up with ways of trying to solve these problems as teachers, but connectivity at this school is affecting us a lot" (Mr Bhengu). "There is no Wi-Fi connection in the area or there is load-shedding we struggle to be taught… that delays us more in learning because we should wait for the Wi-Fi [to be] connected" (learner).	No Wi-Fi access/ affects teaching and learning.	Unavailability of Wi-Fi: both teachers and learners cited the unavailability of Wi-Fi access as a challenge that affected teaching and learning negatively.
"… they basically use L-Block as the face for the school. When we were in Grade 8, they only showed us L-block because the classes are 5-star, network fast, everything went proper. When you come to uhm C-Block, the Wi-Fi is busy authenticating" (learner).	Wi-Fi access not the same throughout the school/deception.	

"For two years we have been off-line in terms of Wi-Fi"

This was the situation regarding Wi-Fi access at Iziphethu Secondary School, an issue that was experienced by the majority of the participants in this study:

> *… sometimes there will be no network so we can't access the internet or any website, during that particular day if the Wi-Fi is not working so we've got challenges on that bit.*

> *… connectivity is affecting us a lot. Ja, so sometimes you have to come up with ways of trying to solve these problems as teachers, but connectivity at this school is affecting us a lot.*

Wi-Fi access is not compulsory for teaching and learning in a paperless environment but would only be necessary when learners are asked to research certain topics or when teachers need to access the Intranet or internet to share resources with learners. Resources required for teaching and learning could be saved on learners' tablets, thus ensuring that teaching and learning continue, irrespective of the unavailability of Wi-Fi. If teachers require the use of Wi-Fi, perhaps planning could obviate this problem because a learner indicated that when "*There is no Wi-Fi connection in the area or there is load-shedding we struggle to be taught… that delays us more in learning because we should wait for the Wi-Fi [to be] connected"*.

Another learner indicated:

> *… they basically use L-Block as the face for the school. When we were in Grade 8, they only showed us L-block because the classes are 5-star, network fast, everything went proper. When you come to uhm C-Block, the Wi-Fi is busy authenticating (sarcastic – everyone laughs).*

It is apparent from the above comment that this school presents a false image to attract prospective learners and parents. If Wi-Fi is a necessity for a paperless environment, then Wi-Fi should be available throughout the school during school hours, which is not the case at all the sites. To reiterate, in the 2015/2016 annual performance plan the Gauteng MEC mentioned *"… we will work towards introducing smart paperless classrooms to ensure that all learners and teachers have progressive access to broadband and innovative learning and teaching tools which will enable learners to meaningfully participate in the economies of the future"* (see Chapter One). However, this is certainly not the situation at any of the sites included in this study as the majority of the smartboards, which I presume are the "*innovative teaching tools*" that the Gauteng MEC referred to, as well as access to Wi-Fi, were major obstacles encountered by both teachers and learners at these paperless schools. Regarding the unavailability of Wi-Fi, a learner posed an important question "*If the school knows there's a problem [with Wi-Fi], why are they not fixing it?"*

Ms Sedibe was the only teacher from all the sites that indicated that she uses the smartboard to conduct formative assessments in Mathematics with her learners. She provided an example where she would pose a question to the learners and they would have to submit their answers to the smartboard including their names. However, during the lesson observation when I requested her to show us how this was done, she indicated that it was not possible. The reason she provided was that the licence for that particular software had not been renewed, therefore, she could not assess her learners using that method. In such an instance the Wi-Fi is necessary. In addition, to teach in a so-called paperless environment, it would be necessary for technology to be working to its optimum and for problems to be addressed immediately. However, the majority of the participants in this study complained that the unavailability of Wi-Fi and the failure of technology had a negative influence on teaching and learning in their classrooms. Apart from the above-mentioned problems, theft, lost and broken tablets were a major challenge that affected one of the cases. A synopsis of the participants' excerpts was used to arrive at the sub-theme "Broken, lost or stolen tablets," as shown in the table below, followed by a discussion on this sub-theme.

Table 6.5 Broken, Stolen or Lost tablets

Representative phrases from participants	Open coding	Axial coding
"… they stole about 200 tablets at the Harry Gwala Centre" (Mr Namane). "… there was burglaries in our school, cables were destroyed… our school was burgled this year about the 5th burglary … from last year it would be, I think more than 10, so this year alone in the space of a month, it's more than 5" (Mr Namane). "… in 2016 things got worse like we lost like 200 tablets, so some didn't get their tablets back" (learner). "The smartboard hard-drives are being stolen… we steal each other's tablets" (learner).	Burglary/tablets stolen. Cables destroyed. Tablets/stolen by learners.	
"… the problem is us, we steal from each other, our community steals from us, so it [paperless environment] ain't working" (learner).	Challenge/no security.	
"I said to them [GDE], ok you are providing ICT but not providing security. The school must hire security because the school doesn't have security at all. So, it's a challenge, it's a huge challenge" (Mr Namane). "… there are learners who have already lost their tablets, some of the tablets are damaged" (learner). "… for those that are stolen, it becomes a challenge to the learners" (learner). "… some of the learners you will find that the tablet is broken or everything in the tablet it's shut down" (learner). "… most of the screens they are cracked so they can't use it properly" (learner).	Challenge/lost/damaged/stolen tablets.	Broken, stolen or lost tablets: this was a major challenge experienced at all four sites.
"… loss of tablets and the stealing internally from the school, learners stealing tablets from each other … and two, parents themselves telling learners to lie that the tablets is lost" (learner). "It's a new challenge that I realised this year, where parents say there was a burglary at home, they only stole the tablet" (Mr Namane). "… some other students just prefer to come to school and just steal other people's stuff which is not right, it causes a lot of strain in our parents, stress and all that because they if it gets stolen or broken they have to fix it themselves and that's quite a huge gap in a budget because some other parents are not prepared for things of that sort" (learner).	Learners stealing from one another. Parents/deception. Financial burden.	
"… when the tablet is lost or not working the parent must pay half, but when he makes these statements saying that if there is a burglary if they want the tablet, don't fight, give them, we'll give you a new one, now it's on us to force this unemployed parent to pay, it's impossible… I'm not a cop if the parent comes and say… my child's tablet is stolen at home; I have to write their MEI number and say go to the police station and open a case. I can only take a case number, record it, attach that to the affidavit. I can't really be saying 'you are lying as a parent' although sometimes you can tell that this story is off" (Mr Namane).	Procedure to be followed/stolen tablets/policy. Additional burden placed on teachers.	

"We leave it to the police to investigate but it doesn't go neither here nor there, that's another challenge" (Mr Namane). "… not grateful for what they have… some of us we never had this" (Mr Thuli). "… if you earn something you make sure nobody takes it away from you" (learner). "… these consent forms don't state should you break it or lose it you are going to pay. So now that's where now the problem is … because these children they know even if I can lose the tablet it's not a problem, there's no consequences, you'll [the school] just have to replace it or something" (Mr Thuli). "There is nothing I can do as a teacher; the child just has to make a plan ... We can just inform the parents… that's all we can do on our side" (Ms Shabangu). "… tablets are stolen, then you have to replace the learner tablet with a hardcopy textbook so that sort of reverses the whole, the entire paperless system" (Mr Namane).	Challenge/recovery of lost tablets. Learner accountability/none. No policy. Learners without tablets use hardcopy textbook (not paperless).	

"They stole about 200 tablets at the Harry Gwala Centre"

Mr Namane indicated:

> *… there was burglaries in our school, cables were destroyed… our school was burgled this year about the 5th burglary … from last year it would be, I think more than 10, so this year alone in the space of a month, it's more than 5.*

Crime is rife in South Africa and theft of technological devices from schools, whether paperless or not, is a reality. Therefore, the provision of security at schools that use technology, should have been a priority to ensure uninterrupted teaching and learning. It was imperative that the Gauteng MEC takes cognisance of significant preventative measures regarding theft by providing the requisite security infrastructure. However, this is not the case as Mr Namane stated "*I said to them [GDE], ok you are providing ICT but not providing security. The school must hire security because the school doesn't have security at all. So, it's a challenge, it's a huge challenge"*. From the above statement, it is obvious that the GDE provides the technology but does not provide the necessary security to protect against burglaries and theft of devices amongst learners, therefore, the onus is upon the school to provide the necessary security. However, Iziphethu Secondary School is a [7]quintile 1 school, which is a non-fee-paying school,

[7] Schools in South Africa have been categorised into five categories, known as quintiles. These categories are used to determine the amount of funding that will be provided by Government to schools. Quintiles 1, 2 and 3 are no-fee schools which means that learners do not pay school fees and therefore, obtain most of the Government's funding. Since quintiles 4 and 5 get lesser funding from the Government, they are permitted to charge learners school fees that is determined by learners' parents. (Basic Education Rights Handbook – Education Rights in South Africa – Chapter Seven: School Fees)

consequently, funds are very low, and it would be difficult for them to afford the necessary security. If the technological devices are stolen, then teaching and learning is obviously disrupted; as a result, no teaching and learning will be conducted in a paperless environment.

Learners' loss of, damaging and stealing each other's tablets were major setbacks in all four cases as depicted in the following statements by the Mathematics teachers:

> *... there are learners who have already lost their tablets, some of the tablets are damaged.*
>
> *... for those that are stolen, it becomes a challenge to the learners.*
>
> *... some of the learners you will find that the tablet is broken or everything in the tablet it's shut down... most of the screens they are cracked so they can't use it properly.*
>
> *... it's the learners... they [are] messing up everything, breaking up everything... loss of tablets and the stealing internally from the school, learners stealing tablets from each other ... and two, parents themselves telling learners to lie that the tablets is lost.*

What is disconcerting is that parents encourage their children to lie about lost or damaged tablets. Mr Namane confirmed this "*It's a new challenge that I realised this year, where parents say there was a burglary at home, they only stole the tablet"*. However, Mr Namane questions this *"So they left your cellphone, they left the learner's cellphone, they left your TV [and] they [only] stole the tablet?"* That parents are being dishonest, shows learners that dishonesty is acceptable in their parents' eyes, and may encourage the stealing of tablets amongst learners. Furthermore, Mr Namane indicated that the Gauteng MEC stated that:

> *... when the tablet is lost or not working the parent must pay half, but when he makes these statements saying that if there is a burglary if they want the tablet, don't fight, give them, we'll give you a new one, now it's on us to force this unemployed parent to pay, it's impossible, it's impossible. I'm not a cop, if the parent come and say my learner or my child's tablet is stolen at home, I have to write their MEI number and say go to the police station and open a case. I can only take a case number, record it, attach that to the affidavit. I can't really be saying 'you are lying as a parent' although sometimes you can tell that this story is off.*

The above excerpt shows that the use of technology places an additional burden on teachers as they have to contend with parents lying about tablets being stolen or lost. When tablets are stolen or lost Mr Namane added, "*We leave it to the police to investigate but it doesn't go neither here nor there, that's another challenge"*. In a paperless context, this is a serious problem as these learners would be placed at a disadvantage as they would not be able to complete their classwork, homework nor study without a tablet. Considering that these tablets were given to learners at no cost, learners should value these items and according to Mr Thuli, they should be "… *grateful for what they have… some of us we never had this"*. However, the

above discussion indicates that some of the learners do not value the opportunity they have been afforded. Similarly, during the focus group discussion a learner commented, "*… if you earn something you make sure nobody takes it away from you"*. This statement implies that if individuals pay for something they will appreciate and value it, therefore, more care will be taken of the tablets, possibly resulting in fewer being broken or lost. Mr Thuli added that learners and parents are required to sign consent forms, however:

> *… these consent forms don't state should you break it or lose it you are going to pay. So now that's where now the problem is … because these children they know even if I can lose the tablet it's not a problem, there's no consequences, you'll [the school] just have to replace it or something.*

Because there's no accountability explicitly stated in the document signed by parents and learners, it appears that parents are using this as an excuse to evade responsibility for lost or stolen tablets. During the interview when asked what action is taken in such cases, a teacher responded as follows; "*There is nothing I can do as a teacher, the child just has to make a plan … We can just inform the parents… that's all we can do on our side"*. Considering that theft, broken and lost tablets are a common problem experienced at all four cases, this once again confirms that teaching and learning Mathematics in a paperless environment is not viable. Mr Namane pointed out that if "… *tablets are stolen, then you have to replace the learner tablet with a hardcopy textbook so that sort of reverses the whole, the entire paperless system"*.

During the focus group discussions, learners confirmed what teachers verbalised:

> *… some other students just prefer to come to school and just steal other people's stuff which is not right, it causes a lot of strain in our parents, stress and all that because they if it gets stolen or broken they have to fix it themselves and that's quite a huge gap in a budget because some other parents are not prepared for things of that sort.*
>
> *… in 2016 things got worse like we lost like 200 tablets, so some didn't get their tablets back.*
>
> *… we are not moving forward because the tablets get stolen amongst us. The smartboard hard drives are being stolen. So, the Government cannot do further with these projects of paperless classrooms because we steal each other's tablets and so forth.*

Both teachers and learners highlighted that theft was a major obstacle to achieving a paperless environment at their schools. For a paperless environment to be viable it requires "buy-in" from all stakeholders, including the community, because a learner *stated "… the problem is us, we steal from each other, our community steals from us, so it [paperless environment] ain't working"*. Apart from theft, both teachers and learners cited the inappropriate use of technology as an additional problem that had a negative influence on teaching and learning.

The "inappropriate use of technology" is the next sub-theme, which is summarised in the table below, before proceeding to the discussion of this sub-theme.

Table 6.6 The Inappropriate Use of Technology

Representative phrases from participants	Open coding	Axial coding
"… they are not using those tablets for educational purposes" (Mr Maphosa). "… if you open their tablets now, you will find there's so many games inside, there's no educational stuff on their tablets, they have photos… they play games… they are always playing games" (Mr Maphosa). "… a child is downloading porn on the tablet, is one of the challenges" (Mr Namane). "… they use the tablets for their own use because they go to the website like you are teaching learners, they are playing games, others they are playing music… they are not using the tablet for educational use" (Ms Madi). "Learners were using tablets mainly to play games… you'll think… they are looking at their textbook while they are playing games…you are busy teaching and children are just busy WhatsApping each other" (Ms Shabangu). "I have seen a few in the classroom, listening to music during the period of Maths, I don't know how music and Maths, so ja they use tablets for wrong reasons" (learner).	Tablets/no educational software. Inappropriate use. Learners distracted.	
"… distracted easily in class with games, WhatsApp, Social media instead of actually doing work and that's where the problem was" (learner). "… most of my friends they were using the tablets to play games in other subjects during that period and they were not concentrating" (learner). "… it is a distraction because as soon as the teacher starts explaining you get bored" (learner). "… you'll find that you are teaching in class, they are playing games in their tablets and they can easily hide it, those things" (Mr Mdluli). "So, I think that's the major challenge … of not focusing they go and switch on social media instead of studying" (learner). "They are using [tablets] for their own personal use because some of them I found some other learners they are chatting [WhatsApp] during teaching and learning" (Ms Madi). "Learners, they misuse the technology you won't be able to practice using the tablet because once they see tablets, they think of social media, WhatsApp, in class they don't concentrate" (learner).	Tablets/learner distraction.	

"… you'll be seeing that they will be doing something but by the moment you get to a child, they have hidden it, so for you now to fight with the child, so they will tell you, look at my tablet it's not there" (Mr Mdluli). "… they hide … their tablets… sometimes below the desk, you can't see them, and you have the impression that they are with you whereas they are not there, so it's really a challenge" (Mr Dlamini). "… they don't listen to you, you'll find that underneath the desk on their tablets I mean when you check it's not the work that you are doing, they are doing other stuff" (Mr Sangu). "At home, it is difficult to make homeworks because there is no-one who is looking after you. You can play games and forget about your schoolwork. If you have a textbook it is easier because of you'll know when you put your bag, I have a homework you take the textbook, you write but tablet no-one is watching you, you play games because of your mummy is at work" (learner). "… you can hold your tablet up like this pretend you are reading your textbook whereas you busy with your own stuff" (learner). "… you lose concentrate [concentration] on what she is saying and it's technology. And when she says take out your tablets, you get excited because you know you not going to work, you going to play a game or you gonna be on WhatsApp or on a social media platform" (learner). "… we… don't listen to the teachers… we will go through our tablets and we will play games and with that [lose] concentration… we don't know what she's saying and when it's exam times we don't know what's actually going on and it's like "oh, my word I should have listened" (learner).	Learner discipline. Lack of focus/do not pay attention. Learner results/negative influence.	Inappropriate use of Technology: learners use the available technology inappropriately, which has a negative effect on their Mathematics results.
"… all your work is on the tablet, then you're going to say "ok I'm going to study for this" but then you don't end up studying. You will see a game, this game, ok WhatsApp I got messages, Instagram and you end up doing those things and it distracts you from the educational" (learner).	The negative influence of tablets.	
"These tablets, they make the learners uncontrollable in class, you can't control them because now if you are teaching some of them, they are putting their earphones on the ears whilst you are explaining in class" (Ms Madi). "… if an educator is not in the class, they [learners] go there, change the settings because now they don't want to learn, they change the settings, play around with it, and even unplug it from the back" (Mr Thuli). "… to be honest… we put songs on the smartboard and dance, yes we watch movies. We dance and we watch movies on the smartboard. I know it's a very bad thing, but we do it anyway" (learner).	Learner behaviour/discipline. Disrespect towards teacher.	

"They are not using those tablets for educational purposes"

There was unanimous agreement amongst the teachers and most of the learners from the focus group discussions that the tablets were not being used for learning. Instead, the tablets were used to download and play music and games, take photographs and watch pornography. The above are confirmed by the following statements from teachers:

… if you open their tablets now, you will find there's so many games inside, there's no educational stuff on their tablets, they have photos… they play games… they are always playing games… a child is downloading porn on the tablet, is one of the challenges.

… you'll find that you are teaching in class, they are playing games in their tablets and they can easily hide it, those things.

So, I think that's the major challenge … of not focusing they go and switch on social media instead of studying.

They are using [tablets] for their own personal use because some of them I found some other learners they are chatting [WhatsApp] during teaching and learning.

Learners, they misuse the technology you won't be able to practice using the tablet because once they see tablets, they think of social media, WhatsApp, in class they don't concentrate.

… they use the tablets for their own use because they go to the website like you are teaching learners, they are playing games, others they are playing music… they are not using the tablet for educational use.

… learners were using tablets mainly to play games ... you'll think… they are looking at their textbook while they are playing games. So that's the main challenge because most learners are doing that and nowadays it's WhatsApping. So, you are busy teaching and children are just busy WhatsApping each other and so those are some of the challenges.

This inappropriate use of the tablet is of great concern to teachers: it distracts learners during lessons and places an additional burden on the teacher to maintain discipline regarding the use of the tablet. Learners behave deviously as they are able to "hide" the inappropriate material on their tablets as Mr Mdluli said, *"… you'll be seeing that they will be doing something but by the moment you get to a child, they have hidden it, so for you now to fight with the child, so they will tell you, look at my tablet it's not there"*. Mr Dlamini concurred *"… they hide … their tablets… sometimes below the desk, you can't see them, and you have the impression that they are with you whereas they are not there, so it's really a challenge"*. Mr Sangu agreed that learners do not pay attention in class as their attention is otherwise distracted, *"… they don't listen to you, you'll find that underneath the desk on their tablets I mean when you check it's not the work that you are doing, they are doing other stuff"*.

Learners confirmed their inappropriate use of tablets:

…when I got here, we were all trying to figure out what to do with those things so we would get distracted easily in class with games, WhatsApp, Social media instead of actually doing work and that's where the problem was.

… you can hold your tablet up like this pretend you are reading your textbook whereas you busy with your own stuff, so ja… it is a distraction because as soon as the teacher starts explaining you get bored, then you say "ok, I got a tablet, I'm gonna play games" and then you lose concentrate [concentration] on what she is saying and it's technology. And when she says take out your tablets,

… you get excited because you know you not going to work, you going to play a game or you gonna be on WhatsApp or on a social media platform.

…most of my friends they were using the tablets to play games in other subjects during that period and they were not concentrating, some of my friends they were using let's say it's Mathematics, they were using the tablets to do another subject.

I have seen a few in the classroom, listening to music during the period of Maths, I don't know how music and Maths, so ja they use tablets for wrong reasons.

… we… don't listen to the teachers… we will go through our tablets and we will play games and with that [lose] concentration… we don't know what she's saying and when it's exam times we don't know what's actually going on and it's like "oh, my word I should have listened".

… all your work is on the tablet, then you're going to say "ok I'm going to study for this" but then you don't end up studying. You will see a game, this game, ok WhatsApp I got messages, Instagram and you end up doing those things and it distracts you from the educational.

The above extracts from the focus group discussions confirmed that learners themselves found tablets to be a distraction and diverted their attention from learning activities. Due to this, they did not concentrate in class and as a consequence performed poorly in the examinations. By learners' focusing on other activities on the tablet, Ms Madi found that "*These tablets, they make the learners uncontrollable in class, you can't control them because now if you are teaching some of them they are putting their earphones on the ears whilst you are explaining in class"*. Learners behaving in such a manner show total disrespect for the teacher, once again placing an additional burden on the teacher to maintain discipline in the classroom while using technology for teaching and learning.

Another discipline issue regarding the smartboard is highlighted by Mr Thuli:

… if an educator is not in the class, they [learners] go there [points to the smartboard], change the settings because now they don't want to learn, they change the settings, play around with it, and even unplug it from the back.

When learners interfere with the settings of the smartboard and switch it off, it is a ploy to disrupt teaching and learning. If the teacher is unable to identify why the smartboard is not working, teaching and learning will not take place until a technician has resolved the problem. Learners are not allowed to "touch" the smartboard, however, they defy this rule and use the smartboard inappropriately "*… to be honest… we put songs on the smartboard and dance, yes we watch movies. We dance and we watch movies on the smartboard. I know it's a very bad thing, but we do it anyway"*. Despite knowing that learners are not allowed to use the smartboard or interfere with the settings as indicated by one of the teachers during the

interviews, learners persist with this deviant behaviour. The inappropriate use of tablets continues when learners leave the school premises:

> *At home, it is difficult to make homeworks because there is no-one who is looking after you. You can play games and forget about your schoolwork. If you have a textbook it is easier because of you'll know when you put your bag, I have a homework you take the textbook, you write but tablet no-one is watching you, you play games because of your mummy is at work.*

The above learner cited the absence of parental supervision as one of the contributing factors to the inappropriate use of the tablet and stated quite categorically that the distraction of having a tablet would be eliminated if he had a hardcopy textbook from which to work. The current tablets that are being used by both teachers and learners at the selected sites are problematic. Excerpts from participants regarding how the current tablets are problematic are summarised in the table below:

Table 6.7 The Unsuitability of Tablets and One Smartboard for Teaching and Learning

Representative phrases from participants	Open coding	Axial coding
"… the screen that they are even using it's too small" (Mr Thoko). "… the challenge with the whiteboards is, you know Maths needs a lot of elaboration so sometimes … the space on your screen will not be enough and it delays you" (Mr Thoko).	Tablet screen size inadequate.	The unsuitability of tablets and one smartboard for teaching and learning: teachers found that tablets and having only one smartboard installed per classroom were not suitable for the teaching of Mathematics.
"… the Huawei tablets they don't have adequate space, so to supplement they had eh, external 16Gb SD cards that were loaded with content" (Mr Namane). "… if you [are] talking 32Gb internal memory, 32Gb external memory, it's not a lot of storage. So that's also another limitation because even with the work that they download for instance they would download a video after a while they would need to delete that video because otherwise, it would take up a lot of space" (Mr Mbatha).	Inadequate storage on tablets.	
"… we find that the different tablets that we are using are not at the correct level. Some of them are good tablets but some of them are actually not designed for education. The reason I'm saying that for instance, we are using Snapify to download e-books. Some of the tablets are not able to work with Snapify" (Mr Mbatha).	Tablets not suitable for certain software.	
"… it is difficult for me to just always use the smartboard because I have the textbook which is on my laptop and I can use that, same with the note-book but I can't write on the same board and be able to look at the textbook at the same time" (Ms Shabangu).	One smartboard per classroom is not adequate.	

A discussion of the sub-theme as found in the above table is presented next.

"The screen that they are even using, it's too small"

Teachers from Intaba Secondary School make use of the smartboard software on their tablets to project their lessons on a whiteboard as they do not have smartboards fixed to the classroom walls. Mr Thoko found that the screen size of the tablet that he used was not adequate to teach Mathematics, which is evident from the following statement:

> *... the challenge with the whiteboards is, you know Maths needs a lot of elaboration so sometimes ... the space on your screen will not be enough and it delays you. Sometimes as I put aside [the tablet] and go with [use] the marker to do more elaboration because some of the concepts is quite long to explain. I'm using uhm the board from the tablet, therefore, I do part [of the lesson] and I move to another page it's not quite uhm smooth.*

The Gauteng MEC requires teachers to work in a paperless environment and has provided tablets for both teachers and learners for the purpose of teaching and learning. However, as pointed out by one teacher, the size of the tablet screen was unsuitable and as a result, he often had to put aside the tablet and resort to writing on the whiteboard to provide a detailed explanation to learners. Drawing on his experience, this teacher highlighted the importance of the presence of a whiteboard in the classroom and the unsuitability of the sole use of technology to teach Mathematics. This strengthens teachers' preferences for teaching and learning to take place in a blended environment and once more queries the viability of teaching and learning Mathematics in a paperless context.

Two ICT committee members indicated that the storage capacity on the learners' tablets was insufficient:

> *... the Huawei tablets they don't have adequate space, so to supplement they had eh, external 16Gb SD cards that were loaded with content.*

> *... if you [are] talking 32Gb internal memory, 32Gb external memory, it's not a lot of storage. So that's also another limitation because even with the work that they download for instance they would download a video after a while they would need to delete that video because otherwise, it would take up a lot of space.*

Learners require these additional resources to study for assessments and as reference material. In the event of having to continuously delete resources from their tablets, they would not have a record of the material and would consequently be forced to make hardcopies. For teaching and learning to take place seamlessly in a paperless environment, it is incumbent upon the GDE to provide technology that adequately satisfies the needs for teaching and learning. Mr Mbatha stated:

> *… we find that the different tablets that we are using are not at the correct level. Some of them are good tablets but some of them are actually not designed for education. The reason I'm saying that for instance, we are using Snapify, to download e-books. Some of the tablets are not able to work with Snapify.*

If the storage capacity of the tablet is limited or cannot accommodate the use of certain applications, it would affect teaching and learning adversely. Some of the teachers at all the sites complained that learners' tablets only had the textbook loaded as a resource, whereas teachers had access to additional software. Mr Namane expressed the importance of learners' tablets and the smartboard having identical software:

> *I think it's practical provided there can be that link between what the learners have as a software on the tablet with what we have on the smartboard because on the smartboard we have an application, a notebook and that notebook has all sorts of interactive media eh, so as you are putting sums it automatically draws a graph… but the learners don't have it on their tablets.*

For Mathematics, learners must practice the concepts being taught to master those skills. However, if teachers are using specific software to demonstrate Mathematical concepts but learners do not have the same software on their tablets, it prevents them from practicing those concepts on their tablets. In a paperless environment, it is essential that learners have the requisite software loaded on their tablets that will assist them to learn Mathematics.

At many of the sites, the classrooms are equipped with only one smartboard. Ms Shabangu found that just having one smartboard was not adequate to teach Mathematics as she indicated:

> *… it is difficult for me to just always use the smartboard because I have the textbook which is on my laptop and I can use that, same with the note-book but I can't write on the same board and be able to look at the textbook at the same time.*

The problem of having only one smartboard was mentioned by several teachers. If these teachers project the textbook onto the smartboard, then they cannot access all the available features on the smartboard, as a result they resort to using either the chalkboard or the whiteboard. It was observed during the Mathematics lessons that some teachers from all the sites did exactly that. The above discussion provided evidence of the necessity of either a whiteboard/chalkboard in the classroom. Despite the MEC's confidence that teaching and learning at Gauteng schools would take place in a paperless environment, the above discussion provides evidence contrary to his expectations of a paperless classroom. Since the GDE is responsible for the provision and the maintenance of the technology at the respective paperless schools as well as being the caretakers of education, it is important to discuss whether the

requirements of the district subject facilitators have changed for paperless schools. Table 6.8 below contains excerpts of teachers' experiences regarding the requirements of subject facilitators from the district, followed by a discussion on this sub-theme.

Table 6.8 GDE Requirements

Representative phrases from participants	Open coding	Axial coding
"… reporting from [to] the district, it is entirely fully on paper… the filing also still, [they] want hardcopy paper, they don't want soft files, soft educator files" (Mr Namane). "We plead with facilitators that we are going soft-line, we can start by building these soft files and even I said sometimes you don't need to come to school, I can email you the files" (Mr Namane). "… they want learner books, physical books. So, to say, they won't write in books, their report is going to say 'Mr Namane doesn't do his work, that's their report. Two, I've tried to have, I'm teaching English, I've developed a soft file, I used to fight a lot with my facilitator because the reports kept on saying: Mr Namane doesn't have a file but I said, 'this is my file'. We fought a lot with the facilitator verbally, one said I don't have [an] interest in my job, I don't care about the learner, but I said here's the [file]" (Mr Namane). "… monitors [subject facilitators] when they come here, they don't ask for the tablets, they ask, they want the books for the learners to see whether you are working or not" (Ms Mashego). "… the district, they are looking forward for seeing work being done on classwork book and eh having a file, with hardcopies seeing the question papers from the previous exams like in my case in Grade 12, they always want to see an evidence of the tracking of the past exam question papers from the book, so it's a matter of the integration between the gadgets and the paper" (Mr Nkosi).	Misalignment between GDE and district requirements. District requires hardcopies. Softcopies not acceptable/accusations levied against a teacher.	GDE Requirements: there seems to be a misalignment between the GDE requirements and the district subject facilitators.
"The GDE have provided us with this file, this big file and that file is not electronically installed on the smartboard, so I think… we are still using the old system" (Ms Madi). "… must first check that lesson before you present it to the learners because you will find that there are some mistakes" (Ms Mashego). "… lesson plans that were prepared by someone else, at times you might find there is some challenges or there are some, where you need to do some corrections" (Ms Sedibe). "… the way they present it [lessons], it's not the way you present it. So, some of them you prefer to… prepare them on your own" (Ms Mashego).	Hardcopy prepared lessons provided by the GDE. Prepared lessons contain errors. Prepared lessons are restricting/teaching styles.	
"… there's no paperless. How do you work paperless with a file?" (Mr Sangu)	Question of paperless vs. a file.	
"… they gave me some PowerPoint presentations to use to teach in class. I tried for the first few weeks, I was frustrated, I mean new environment, new, nah aha, so I dumped it. I went back to my old ways, my old ways, when I take a topic, I start from scratch I build my learners up, I, you know, make it interesting" (Ms Mbheki).	PowerPoint presentations to teach Mathematics. Teacher frustration.	

"The district wants on paper"

The above sub-heading clearly indicates that the GDE has not changed their policy with regards to paperless schools as they still insist on hardcopies of information from teachers as stated by Mr Namane:

> *... reporting from [to] the district, it is entirely fully on paper... the filing also still, [they] want hardcopy paper, they don't want soft files, soft educator files. So, it's difficult because as a school we want to be paperless but in terms of reporting we are now forced or compelled at some point to go back to paper.*

Mr Namane is adamant that the Gauteng MEC's statement is "*far from reality"*. Despite him trying to function in a paperless environment, it is inhibited by the demands of the GDE subject facilitators. He said "*We plead with facilitators that we are going soft-line, we can start by building these soft files and even I said sometimes you don't need to come to school, I can email you the files"*. He elaborated on the GDE's insistence of hardcopy reports and learner books despite him pointing out that they are a paperless school and that all his files are electronic. He was subsequently accused of not doing his job:

> *... they want learner books, physical books. So, to say, they won't write in books, their report is going to say 'Mr Namane doesn't do his work, that's their report. Two, I've tried to have, I'm teaching English, I've developed a soft file, I used to fight a lot with my facilitator because the reports kept on saying: Mr Namane doesn't have a file, but I said, 'this is my file'. We fought a lot with the facilitator verbally, one said I don't have [an] interest in my job, I don't care about the learner, but I said here's the [file].*

The above claim is supported by Ms Mashego who added, *"... monitors [subject facilitators] when they come here, they don't ask for the tablets, they ask, they want the books for the learners to see whether you are working or not"*. Mr Nkosi concurred:

> *... the district, they are looking forward for seeing work being done on classwork book and eh having a file, with hardcopies seeing the question papers from the previous exams like in my case in Grade 12, they always want to see an evidence of the tracking of the past exam question papers from the book, so it's a matter of the integration between the gadgets and the paper.*

If a school is functioning in a paperless environment, it is assumed that all documentation would be electronic. However, there seems to be a disparity between how a paperless school should function, as envisioned by the Gauteng MEC, as opposed to the requirements of the GDE subject facilitators as indicated above. Since the GDE requires learners' books and hardcopy reports as evidence, this constitutes teaching and learning in a blended environment.

At two of the selected paperless sites, teachers complained that "*The GDE have provided us with this file, this big file and that file is not electronically installed on the smartboard, so I think… we are still using the old system"*. The files as mentioned by the teachers contain lesson plans developed by teachers who were contracted and paid by the GDE to do so. Teachers were instructed to use these lesson plans, however, Ms Mashego found errors in the prepared lesson plans and cautioned that one "*… must first check that lesson before you present it to the learners because you will find that there are some mistakes"*. Ms Sedibe from the same school added, "*… lesson plans that were prepared by someone else, at times you might find there is some challenges or there are some, where you need to do some corrections"*. Although the prepared lessons had errors, she indicated that it saved her time regarding lesson preparation. However, Ms Mashego pointed out that *"… the way they present it [lessons], it's not the way you present it. So, some of them you prefer to… prepare them on your own"*. Because teachers employ a variety of teaching styles that are adapted to learners' needs, these prepared lessons by the GDE become prescriptive and therefore, cannot be used as a "one-size-fits-all" approach. Bearing in mind that teachers are required to use this file in a paperless classroom, Mr Sangu commented *"… there's no paperless. How do you work paperless with a file?"* This is a profound question because it negates the viability of teaching and learning in a paperless classroom.

Over and above the files that were provided, teachers at Illungelo Secondary School were given PowerPoint presentations of prepared lessons to be used in the Mathematics class. Ms Mbheki voiced her experience when she tried to use these lessons:

> *… they gave me some PowerPoint presentations to use to teach in class. I tried for the first few weeks, I was frustrated, I mean new environment, new, nah aha, so I dumped it. I went back to my old ways, my old ways, when I take a topic, I start from scratch I build my learners up, I, you know, make it interesting.*

These are the words of a seasoned Mathematics teacher; because of her unique teaching style found that the PowerPoint presentations did not work for her. Mathematics is a subject that requires considerable explanation and practice as indicated by most of the teachers. Considering that Ms Mbheki has a specific teaching style that has worked for her for many years, she found that the PowerPoint presentations were not suitable for her teaching and learning. As a result, she reverted to her "old style" of teaching Mathematics, which she firmly believed was "tried and tested". By just expecting teachers to use PowerPoint presentations to teach Mathematics without indicating whether there is any value in using this method of

teaching, is unfair to both teachers and learners. Once again, the expectation that teachers must use PowerPoint presentations to teach Mathematics is prescriptive and does not take cognisance of an individual's teaching styles.

Furthermore, by prescribing how lessons should be taught, teachers are not allowed to be innovative. If technology is to be used successfully in the classroom, training is fundamental. Table 6.9 below provides a summary of the open codes and the axial code after the data collected from the participants were analysed. Thereafter, a discussion follows on the sub-theme "inadequate training", however, once again the sub-heading is the actual words of one of the participants that clearly portrays their opinion on the training that they had received pertaining to the use of technology.

Table 6.9 Inadequate Training

Representative phrases from participants	**Open coding**	**Axial coding**
"I think we do need training, more intense training" (Mr Namane).	Require more training.	
"We have a wide variety of teachers, from teachers with no ability to use computers to teachers that can actually use it without problems. But what we've done at our school is that we've actually trained educators, if we introduce smartboards, we train the educators if we give them a laptop, we train them on how to use it" (Ms Smit).	Teachers trained when new technology is introduced.	
"… what… we did was when we introduced smartboards, we then had to train them on how to use the smartboards… At first, we used the service providers that were supplying us with the equipment but at the end when they were gone, we used our ICT champions… so… the training is ongoing… so whenever we see that teachers are battling with something immediately we organise training, not a long training maybe an hour a day, at a particular time then to ensure that everybody is confident in terms of doing what needs to be done" (Mr Mbatha). "… training has to be an ongoing process, not two months, eh once a month program, no, it's supposed to be ongoing" (Mr Namane). "… it was just short training, that's why I said maybe if [we] can have this ongoing training maybe after every quarter they take us on this training" (Mr Maphosa). "… if maybe the department can retrain us, maybe for a long period" (Ms Madi). "Us as educators we still need a lot of staff development on this technology" (Mr Mdluli).	Ongoing training Lack of technological skills.	
"We had to teach or train our educators on basic computer literacy, that is the use of Word, Excel, PowerPoint, Access. So that is where we started, we started by training them on how to	Training/computer literacy skills.	

use computers because some of them didn't even know where to switch on the computer" (Mr Mbatha). "We have trainings almost all the time. Most of the time there is training for some software or something, so there is always training that is being offered… how to use the smartboard… they also do offer training on how to use GeoGebra, how to use different software" (Ms Shabangu).	Training on GeoGebra.	
"Those trainings will be… very useful but for people who are actually experienced and know the technology, it feels more like a waste of time" (Ms Shabangu). "… if you have educators… who are on expert level why train them with the beginners because it takes away interest? Take an educator who is a beginner, immediately catapult them into an expert level, they are completely lost" (Mr Namane). "… we do [a] survey [of] educators… That survey informs us who must be trained at beginner's level, intermediate and expert levels but we still not receiving that training… training has not been segmented correctly as done by the district office" (Mr Namane). "… that the training wasn't well protracted… didn't have a clear objective" (Mr Namane).	Training not aimed at different skill levels of teachers/teachers lose interest. Training/no clear objective.	
"… there were no proper ways of teaching some of the people how to go about with the whole thing, that is why even here at school, you find that other teachers we still use the chalkboard" (Mr Sangu). "… it should be subject related because we never had any training on that one, we are still lacking on that one. What they did is, it was a general training, what we want to have is, if I am teaching Maths it should be at least… training on Maths and then how to use the smartboard, what are the features that [are] related to my subject?" (Mr Maphosa) "… actually, I was trained not on Mathematics, how to use technology on Mathematics, I was trained to use technology on Science that is Life Science, not on Mathematics. No, actually they did not train us how to use technology in class on Mathematics, so that is why even now I have challenges of how to use technology in class. The problem, I'm not teaching Science at the moment" (Ms Madi).	Training/not suitable. Training/not subject-specific. General training.	
"… when they introduced this new system of paperless there were some people who used to come to our school to workshop us on how to use the technology but now no-one make a follow-up to us to find out whether… we now know how to use it or not" (Ms Madi). "I don't think they give these educators much time… to be able to operate these boards because some educators I can show them something today and I'm still going to show it to them again tomorrow" (Mr Thuli).	No follow up after training.	

"I think we need more training… with me like I said I'm not yet ready because I'm still lacking the skills" (Mr Maphosa). "Some of the apps I don't even know them because we… did not get enough workshops [training]" (Ms Madi). "There are some teachers who aren't as advanced as other teachers, who don't know how to use the smartboards" (learner). "Our teachers [don't] know how to use smartboards, they don't know how to use smartboards" (learner). "I've noticed at times with some teachers they don't really know what they are doing with technology and it also wastes time as you [are] learning. I feel like the teacher should have, like really a lot of training for it so that when they get to class, they should know more than us" (learner). "She will ask us how to use the board" (learner). "She struggles to save the notes that she writes on the board and most of the time they get lost, so she will ask us "what do you do when this is lost" and how to save the notes" (learner). "Even myself I still need training on the exit of intermediate to the expert level because I can develop content but there are also software which I … need to know… I still need more training" (Mr Namane).	Need more training. Teachers/lack of technological skills.	
"… it also starts on top, the management itself. I feel that the training has been bottom-up which is supposed to be top-down. You start with the school management so that they can also be ICT driven and ICT aware, then we can pull the staff together, hoping that the SGB is trained so that they understand that we are in an ICT school" (Mr Namane).	Training/ management/SGB. Management/SGB/ support.	Inadequate training: teachers and learners indicated that they required more training.
"… training eish, for me it's really not good because some of them, those people… who are trainers they are not good, some of them they are not good … he or she is not prepared, well prepared so the way he or she is teaching it is not really good, it is not effective for me" (Mr Khoza). "… even those ones who were supposed to train us, are not there yet themselves" (Ms Mbheki). "… even the people that are… supposed to be training us, sometimes because it's machines, sometimes they get confused" (Ms Mbheki).	Trainers lack training skills. Trainers unable to train teachers effectively.	
"… introduce maybe a course whereby the teachers will enroll for this course… where we will be equipped with the skills to use the technology because at the moment, I don't think it will work" (Ms Madi).	Compulsory training.	
"… if we can get proper people who can really service the smartboard… the teachers can be taught how to go through the smartboard [troubleshoot]… because now you find the person from outside, he comes and goes and the minute he went out of the school, the smartboard collapses [does not work]. At the end even if reported they don't attend to it" (Mr Sangu).	Teacher/training on troubleshooting	
"… me and my colleagues sometimes what we do, we always tell these educators that should you have free time… they should just come through, we get a class [room] that is empty and then we do anything that they require from us... I think it was 2 weeks back whereby I made a notice saying that 'if you are an educator you need help with the smartboard or anything please come through' and I never receive, not even one" (Mr Thuli).	Training/Harry Gwala support staff. Teachers disregard offers of support.	
"I'm not exactly perfect but I can, I try using it as best as I can" (learner). "Average, I cannot say I'm good and I cannot say I'm bad" (learner). "My technology skills aren't that good" (learner). "I'm not really good at technology" (learner).	Learner technology skills.	

"Sometimes I struggle to download the notes that the teachers tell us to download and I've not be able to do my homework" (learner).		
"… to take care of those tablets, how to use the tablets, what are they for? Because now they don't use them as they are supposed to. You'll find that textbooks are there in the tablet, but after a week you'll find they've erased them, there's music, there's videos in that because they don't know what to do with it" (Mr Sangu).	Learner training/caring for tablets.	
"… what we do every year when we, our new Grade 8's come in, we have a day or two that they sit in the hall and we go through them and say 'alright, this is how you use your tablet, this is where you download your books, this is how you open your books'. So, we give them a rundown on how they basically use it and what they can find where in this school's portal" (Ms Smit).	Tablets/orientation training.	

"I think we do need training, more intense training"

Teachers and learners should have been trained on how to use the required technology before its introduction in the classroom because Ms Smit pointed out:

> *We have a wide variety of teachers, from teachers with no ability to use computers to teachers that can actually use it without problems. But what we've done at our school is that we've actually trained educators, if we introduce smartboards, we train the educators, if we give them a laptop, we train them on how to use it.*

Mr Mbatha, the Deputy Principal at the same site added:

> *We had to teach or train our educators on basic computer literacy, that is the use of Word, Excel, PowerPoint, Access. So that is where we started, we started by training them on how to use computers because some of them didn't even know where to switch on the computer.*

Furthermore, he stated:

> *… what… we did was when we introduced smartboards, we then had to train them on how to use the smartboards and it worked very well. At first we used the service providers that were supplying us with the equipment but at the end when they were gone, we used our ICT champions… so… the training is ongoing… so whenever we see that teachers are battling with something immediately we organise training, not a long training maybe an hour a day, at a particular time then to ensure that everybody is confident in terms of doing what needs to be done.*

Ms Shabangu, a colleague of the above two participants agreed:

> *We have trainings almost all the time. Most of the time there is training for some software or something, so there is always training that is being offered… how to use the smartboard… they also do offer training on how to use GeoGebra, how to use different software.*

However, she indicated that *"… those trainings will be… very useful, but for people who are actually experienced and know the technology, it feels more like a waste of time",* which indicated that the training was not tailored to the technological experience of the teachers. As

a result, this did not satisfy teachers' individual needs nor targeted the various technology skill levels of each teacher. Mr Namane confirmed that *"… if you have educators… who are on expert level why train them with the beginners because it takes away interest? Take an educator who is a beginner, immediately catapult them into an expert level, they are completely lost"*. He therefore advocated:

> *… we do [a] survey [of] educators. Do you know how to switch on a smartboard? Do you know how to put on an HDMI cable? That survey informs us who must be trained at beginner's level, intermediate and expert levels but we still not receiving that training… training has not been segmented correctly as done by the district office, they are supposed to do so, it's not been adequately done.*

In addition, he indicated *"… that the training wasn't well protracted, didn't have a clear objective and… training has to be an ongoing process, not two months, eh once a month program, no, it's supposed to be ongoing"*. Mr Maphosa from Isilomo Secondary School concurred *"… it was just short training, that's why I said maybe if [we] can have this ongoing training maybe after every quarter they take us on this training"*. Ms Madi echoes this sentiment "… *if maybe the department can retrain us, maybe for a long period"*. Since the training was inadequate and teachers did not feel confident to use the smartboard they reverted to the use of the chalkboard, according to Mr Sangu, *"… there were no proper ways of teaching some of the people how to go about with the whole thing, that is why even here at school, you find that other teachers we still use the chalkboard"*.

Apart from pointing out that training should be ongoing, Mr Maphosa indicated that this training should not always be "*general training"* but:

> *… it should be subject related because we never had any training on that one, we are still lacking on that one. What they did is, it was a general training, what we want to have is, if I am teaching Maths it should be at least… training on Maths and then how to use the smartboard, what are the features that [are] related to my subject? Now if you combine all the teachers teaching Geography whatever, we don't get anything, but if it should be at least subject-specific, it would be better then.*

Mr Maphosa has drawn attention to a significant point; general training on Word, PowerPoint, Excel and Access should be the basic skills in which every teacher should be proficient. Once proficient with these skills, it is then necessary to concentrate on training on the selected technology to teach subject-specific content. This subject-specific training will enable teachers to realise the benefit of the chosen technology as well as to decide its suitability to teach specific Mathematical content. As all teachers are not at the same technological skill level, each school must group the teachers according to their skill levels, before conducting any training.

Despite Ms Madi having received training, she saw the training that she received as challenging because:

> *I was trained not on Mathematics, how to use technology on Mathematics, I was trained to use technology on Science, that is Life Science, not on Mathematics. No, actually they did not train us how to use technology in class on Mathematics, so that is why even now I have challenges of how to use technology in class. The problem, I'm not teaching Science at the moment.*

It is apparent that in addition to the "general training" of basic computer literacy skills, as well as subject-specific training, when a teacher is reallocated another subject to teach, it is imperative that they receive the appropriate training to integrate technology for that particular subject. Despite Ms Madi having been trained to use technology to teach Life Sciences, she did not receive training to use technology to teach Mathematics. Consequently, she is placed at a disadvantage as she claimed that she did not have the requisite technical skills to incorporate technology in her Mathematics classes. In addition, she pointed out:

> *… when they introduced this new system of paperless there were some people who used to come to our school to workshop us on how to use the technology but now no-one make a follow-up to us to find out whether… we now know how to use it or not. No one make a follow-up, they just come and show us that there is this, you can assess this on the smartboard, there is this work you can use it for that, for this learning areas, is it useful for this and that but after that, no one will come and say and see whether the teachers, are they able to access that website or not? No, it ends there*.

From the above excerpt, ongoing subject-specific technological support is a priority to ascertain whether teachers attained the relevant ICT skills during training and if they were able to adequately use these skills. With ongoing support, it would be possible to identify what additional training teachers require. This appears to be the "cry" from a number of teachers at all four sites. If technology is to be used for teaching and learning in a paperless environment, then teachers' technology skills should be impeccable. If teachers' technological skills are lacking, which is evident from the above discussion, *what then happens to teaching and learning since only technology is supposed to be utilised in a paperless environment*? However, if this was a blended environment, which was the situation at all four sites, teaching and learning could continue using the traditional method, while incorporating technology.

Teachers have the confidence to present the Mathematical content using the traditional teaching methods as this is how they were trained. However, when faced with no choice regarding the use of technology as in a paperless environment, they feel overwhelmed, due to their lack of technological skills. In a blended environment, teachers may continue using a teaching method with which they feel comfortable, while incorporating technology, based on their skill levels.

Mishra and Koehler (2006) pointed out that the combination of technological knowledge, pedagogical knowledge as well as content knowledge is key when digital technologies are incorporated in teaching and learning. TCK refers to the understanding of how digital technology and content influence and limit each other. Thus, teachers should be able to recognise, which digital technologies would be appropriate to present specific Mathematics content as this determines the technology to be used. Consequently, for teachers to integrate ICTs in the Mathematics classroom, TPK is key. Taking cognisance of TPK, a blended environment provides teachers with the opportunity to make informed choices regarding the use of technology, whereas a paperless environment does not. Therefore, from the above discussion it is evident that a paperless classroom will not be viable because the excerpts below highlight Mathematics teachers' current ICT skills:

> *Us as educators we still need a lot of staff development on this technology.*
>
> *I think we need more training… with me like I said I'm not yet ready because I'm still lacking the skills.*
>
> *Some of the apps I don't even know them because we… did not get enough workshops [training].*

Learners remarked:

> *There are some teachers who aren't as advanced as other teachers, who don't know how to use the smartboards.*
>
> *Our teachers [don't] know how to use smartboards, they don't know how to use smartboards.*
>
> *I've noticed at times with some teachers they don't really know what they are doing with technology and it also wastes time as you [are] learning. I feel like the teacher should have, like really a lot of training for it so that when they get to class, they should know more than us.*
>
> *She will ask us how to use the board.*
>
> *She struggles to save the notes that she writes on the board and most of the time they get lost, so she will ask us "what do you do when this is lost" and how to save the notes.*

Mathematics' learners statements as presented above, corroborate teachers' acknowledgment of their lack of skills to incorporate technology in the classroom, to which a learner asked a pertinent question "*It seems the teachers went for training for this but did the training really help them after all?"*

Mr Namane, although being highly skilled in the use of technology, believed that "*Even myself I still need training on the exit of intermediate to the expert level because I can develop content but there are also software which I … need to know… I still need more training"*. However, he

is of the opinion that the onus is not only on the GDE to provide such training, but the schools should play a more important role and take responsibility for additional training "… *it's not entirely the fault of the GDE, you can't rely heavily on them"*. He believed that

> *… it also starts on top, the management itself. I feel that the training has been bottom-up which is supposed to be top-down. You start with the school management so that they can also be ICT driven and ICT aware, then we can pull the staff together, hoping that the SGB is trained so that they understand that we are in an ICT school, we are not in a normal eh school, that consumes a lot of paper because in our training we were told that we should go back to our SGB's and recommend that they streamline part of the budget to ICT resources. But it's still not happening when you speak of ICT either to the principal, either to the SGB, you [are] speaking something different.*

Mr Namane was the only participant, who stated quite categorically that training is a shared responsibility between the GDE and the school; and that training ought to be, to use his words "*top-down*" instead of "*bottom-up*", meaning that it should begin with management as they introduced the ICT initiative. If management does not support the teachers regarding ICT integration, *how then can teaching and learning be viable in a paperless environment?*

Regarding the ICT skills of the people, who conducted the training, several participants complained about the quality of the training:

> *… training eish, for me it's really not good because some of them, those people… who are trainers they are not good, some of them they are not good … he or she is not prepared, well prepared so the way he or she is teaching it is not really good, it is not effective for me.*
>
> *… even those ones who were supposed to train us, are not there yet themselves.*
>
> *… even the people that are… supposed to be training us, sometimes because it's machines, sometimes they get confused.*

If the training is not adequate to provide teachers with the requisite ICT skills, it is then doubtful that teachers would be able to conduct lessons in a paperless context. Mr Thuli from the Harry Gwala Support Centre cited a significant issue "*I don't think they give these educators much time… to be able to operate these boards because some educators I can show them something today and I'm still going to show it to them again tomorrow"*. As Mr Thuli pointed out, a "once-off" training session was inadequate to acquire the requisite technical skills to incorporate technology in teaching and learning as there are many aspects to using technology, which cannot be learned in one session. Ms Madi offered a good suggestion *"… introduce maybe a course whereby the teachers will enroll for this course… where we will be equipped with the skills to use the technology because at the moment, I don't think it will work"*. It is evident that teachers are not coping with the integration of technology in teaching and learning;

Ms Madi believes that a paperless classroom will not work. Apart from honing the ICT skills of teachers with a certified course, it will improve their confidence and motivate them to be better equipped to integrate technology in teaching and learning. The incentive of certification would contribute to their qualifications. Mr Sangu also recommended:

> *… if we can get proper people who can really service the smartboard… the teachers can be taught how to go through the smartboard [troubleshoot]… because now you find the person from outside, he comes and goes and the minute he went out of the school, the smartboard collapses [does not work]. At the end even if reported they [technicians employed by GDE] don't attend to it …*

The above two suggestions are valuable; if teachers have the requisite ICT skills and are taught how to "troubleshoot" problems with the smartboard, this may assist them from becoming nervous and "stammering", as indicated in one of the previous excerpts by Ms Madi. In addition, from Mr Sangu's excerpt, it is obvious that he is frustrated as he is not receiving the requisite support, which is mandatory for a teacher to function successfully in a paperless environment. However, Mr Thuli who is a technician from the Harry Gwala Support Centre, from the same site, provides evidence to the contrary:

> *… me and my colleagues sometimes what we do, we always tell these educators that should you have free time… they should just come through, we get a class [room] that is empty and then we do anything that they require from us. Can be helping you in terms of showing you how diagrams work or how the board works... I think it was 2 weeks back whereby I made a notice saying that 'if you are an educator you need help with the smartboard or anything please come through' and I never receive, not even one.*

The above excerpt shows that despite the technicians offering teachers additional help or training, no one at this particular site took advantage of this. However, he did point out that before this request, a few teachers had approached him for assistance.

Because learners can manipulate their cellphones, it does not mean that their skills are adequate to use technology confidently in learning. This is evident in the excerpts below from the focus group discussions with learners:

> *I'm not exactly perfect but I can, I try using it as best as I can.*
>
> *Average, I cannot say I'm good and I cannot say I'm bad.*
>
> *My technology skills aren't that good.*
>
> *I'm not really good at technology.*

It is, therefore, important not to assume that learners born in the digital era, are all technologically "savvy". This is erroneous and dangerous since important decisions might be

based on this flawed assumption. This is precisely the case in this study where all teachers who were participants claimed that learners were "excellent" regarding technology-use, whereas learners themselves indicated their shortcomings.

Mr Sangu was adamant that learners should be trained:

> *… to take care of those tablets, how to use the tablets, what are they for? Because now they don't use them as they are supposed to. You'll find that textbooks are there in the tablet, but after a week you'll find they've erased them, there's music, there's videos in that because they don't know what to do with it.*

If learners are not taught how to care for the tablet, they will use it for the wrong reasons. Consequently, without appropriate training and guidance, learners "abuse" of the tablet would inhibit teachers' efforts to integrate technology in the classroom. As a result, this would be an obstacle to teaching and learning in a paperless environment.

With regards to learner training, Illungelo Secondary School has an orientation programme for learners entering Grade 8 as described by Ms Smit:

> *… what we do every year when we, our new Grade 8's come in, we have a day or two that they sit in the hall and we go through them and say 'alright, this is how you use your tablet, this is where you download your books, this is how you open your books'. So, we give them a rundown on how they basically use it and what they can find where in this school's portal.*

The above excerpt clarifies that learners are introduced to the use of the tablet over "*a day or two*", however, if learners are to use technology solely for learning, the orientation that this school provides, would be inadequate as learners will be expected to use various software packages. In addition, training for learners should also be subject-specific and ongoing. Despite the orientation programme at the beginning of the year, a learner indicated; "S*ometimes I struggle to download the notes that the teachers tell us to download and I've not be able to do my homework"*.

Earlier, Mr Namane indicated that the software that is found on the smartboards should also be loaded on learners' tablets; this is not the case because of inadequate storage space on most of the tablets. However, if teaching and learning is supposed to be successful in a paperless environment, then the learner should be able to perform the same tasks using the same software as the teacher would use to explain a particular concept using the smartboard. Mathematics requires continuous and considerable practice and without the requisite skills, learners would

not be able to practice Mathematical skills. In addition, since the tablets do not contain any software to teach Mathematical concepts, this may result in learners using the device inappropriately. Considering that training regarding the selected technology used in the classroom is essential for both teachers and learners, support is central for teaching and learning to proceed effortlessly in such a context. Table 6.10 below provides a list of participants' excerpts that led to the formulation of the next sub-theme "inadequate support".

Table 6.10 Inadequate Support

Representative phrases from participants	Open coding	Axial coding
"No, the school does not support us" (Mr Maphosa). "I've not got any support" (Mr Museba).	No support from management.	
"… he's got some fewer classes in computers, lower grades but mainly he's for IT… providing us with the IT specialist to assist us and also organising some workshops for us" (Mr Bhengu).	Support/IT specialist. Training by IT specialist.	
"… we had to organise our own ICT champions within the school to offer support to all the staff that were battling in using the technology and obviously the teachers were all, not all at the same level. Some were far ahead than others and then we used the ones that knew more to train the others. So, we took that team of educators and we made them ICT champions and they were the ones that were very instrumental in helping their counterparts" (Mr Mbatha).	Support/ICT champions.	Inadequate support: teachers alluded to not having adequate support with regards to technology integration in the classroom.
"… very good, very good and respectful towards me, being a BBT teacher" (Ms Vermaak).	Good support/BBT teacher.	
"… so, what we basically do here at the Harry Gwala Centre is that should there be any problems regarding any ICT device in the school, that's where we come in. By troubleshooting I mean like we troubleshoot each and every board around the school, checking what's the problem. Should it have any hardware issue, or any software issue, we note it down. So today we are busy troubleshooting, and this is now the list that I have to send to the GDE so that they can send another technician to come and fix all these problems that they are having" (Mr Thuli). "… in terms of hardware fixing, we don't… unless it is something that is really urgent that's where now we have to ask for permission and that's when we do it" (Mr Thuli).	Support/Harry Gwala technicians. Restrictions from GDE/fixing hardware.	
"… last year we had ICT workers but it seemed like they were not doing their jobs because some smartboards were misfunctioning but still, they will just come and say 'ah it's not working and come out[leave]' and that is not acceptable because some learners still want to learn every day in school" (learner). "… service delivery is very poor" (learner).	Inadequate support/ICT technicians. Poor service delivery.	
"… we take back the devices in, we record it then we send it back to the GDE but then for the device to come back or for them	Repairs not timeous by GDE.	

collecting the devices, it becomes a problem now because now they take forever in terms of fixing the devices and bringing them back" (Mr Thuli). "… learner tablets were broken this term, they were supposed to be taken for fixing, they were not. It causes a disruption" (Mr Namane). "… when my tablets broke last year, I actually had to wait a very long period of time… I couldn't do my homework and most of the time the teacher would give me demerits for homework not done because I cannot do the homework cos the textbooks are in the tablets" (learner).	Learners without tablets affect learning negatively. Learners not able to complete homework. Unfair/demerits allocated.	
"… they keep the one that's broken until next year. You need a tablet this year, it's broken January, need it to be fixed in January, you'll get it next year January, 12 months of no studying because your tablet is broken" (learner).	Learners cannot study.	
"… when it comes to school opening because you find that we open this week then the tablet will be delivered maybe after, they will finish deliver tablet or supply tablet to class after 3 weeks and the books are there in their tablets" (Ms Mashego).	Tablets not delivered timeously to schools.	
"… we have blinds, blinds are destroyed eh, the school must re-install blinds… because it is difficult to see on the board because it reflects. I have been saying this for the past two years, you can see that they don't think that if there's the sun, they don't see how difficult it would be for you to use the smartboard, to project something on the smartboard" (Mr Namane). "… the department is slow, but internal politics at times… imagine we didn't have Wi-Fi for 2 years, we waited for the department for 2 years, the school could have done something …because the school has money" (Mr Namane).	Shared responsibility (school and GDE).	
"The budget again from the SGB's it's not streamlined, it's not ICT streamlined. We still buy papers; we spend a lot of the chunk of the school's money to buy papers and buy photocopying ink" (Mr Namane).	SGB budget for paper-based environment.	

"No, the school does not support us"

Support and maintenance are integral aspects of incorporating technology in teaching and learning, as a result, the GDE established a Harry Gwala Support Centre to provide teachers and learners with the necessary ICT support at two of the selected sites, included in this study. The teachers from the private school, Intaba Secondary School, indicated that it was the responsibility of the Information Technology (IT) teacher to provide assistance to teachers requiring support. Because of the additional responsibility of providing ICT support to teachers, Mr Bhengu added *"… he's got some fewer classes in computers, lower grades but mainly he's for IT… providing us with the IT specialist to assist us and also organising some workshops for us"*. Conversely, Mr Museba, who is from the same school said, "*I've not got*

any support". ICT use at this particular school is still in its infancy. All the Mathematics lessons observed revealed that teachers prepared their lessons and merely projected what was on their tablets on an ordinary whiteboard. In addition, as there was only one whiteboard fixed to the wall in each classroom, the teacher had to write on this when necessary.

Illungelo Secondary School is a site that did not have a Harry Gwala Support Centre, however, Mr Mbatha who drives the implementation of ICTs at his school indicated:

> *... we had to organise our own ICT champions within the school to offer support to all the staff that were battling in using the technology and obviously the teachers were all, not all at the same level. Some were far ahead than others and then we used the ones that knew more to train the others. So, we took that team of educators and we made them ICT champions and they were the ones that were very instrumental in helping their counterparts.*

All teachers at this particular school confirmed that they received very good support from these "ICT champions". Ms Vermaak, who regards herself as a BBT (born before technology) teacher, when asked about the support she had received, replied: "… *very good, very good and respectful towards me, being a BBT teacher".* Using the more ICT skilled teachers to support the less skilled teachers has been valuable since the school does not have a Harry Gwala Support Centre on site. This case showed that they were resourceful in creating a team of ICT skilled teachers, who were known as the "ICT champions" at their school. Despite the above two schools not having an established support centre, the technology used in the classrooms was in working order while the remaining two sites that each had a Harry Gwala Centre for the sole purpose of providing ICT support to the school and teachers, had several classrooms where the smartboard was not operational.

Mr Thuli from the Harry Gwala Centre at Iziphethu Secondary School described his responsibilities:

> *... what we basically do here at the Harry Gwala Centre is that should there be any problems regarding any ICT device in the school, that's where we come in. By troubleshooting I mean like we troubleshoot each and every board around the school, checking what's the problem. Should it have any hardware issue, or any software issue, we note it down. So today we are busy troubleshooting, and this is now the list that I have to send to the GDE so that they can send another technician to come and fix all these problems that they are having.*

It is obvious from the above that there would be a time delay in attending to the problem since the procedure requires a report from the on-site technician to be sent to the GDE. Mr Thuli indicated that only once the GDE received the report, would they send out a technician to

resolve the problem. When asked whether the technicians on site are allowed to fix any of the technical problems, he responded "*... in terms of hardware fixing, we don't ... unless it is something that is really urgent that's where now we have to ask for permission and that's when we do it".* A learner from Iziphethu Secondary School stated:

> *... last year we had ICT workers but it seemed like they were not doing their jobs because some smartboards were misfunctioning but still, they will just come and say "ah it's not working and come out[leave]" and that is not acceptable because some learners still want to learn every day in school.*

Learners are under the impression that if there is a technician on-site, the problem would be solved immediately, however, learners are unaware of the fact that technicians are not allowed to attend to technical problems without the permission of the GDE. Therefore, they labour under the misconception that the technicians are not performing their duties. When technology is used, it would be necessary to have a highly skilled technician on site, who would be able to attend to the problems immediately, so that teaching and learning can continue. However, this is not the situation as the technicians that are available are not allowed to "fix" anything prior to seeking permission from the GDE. This procedure deters teachers from using technology, due to time delays in repairing faulty technology. Bearing in mind that the chalkboards and the whiteboards were supposed to be removed from the classrooms, *what happens to teaching and learning in such situations?* Perhaps this is one of the reasons why during my observations I noticed a whiteboard leaning on the wall in one of the classrooms with Mathematics information on it.

Some teachers from two different sites during the classroom observations used the chalkboard or the whiteboard to explain Mathematical concepts while they used the smartboard to display the textbook. The Gauteng MEC was adamant that in these paperless schools, neither chalk nor the chalkboard/whiteboard and the pen nor paper would be used, however, in reality, this was not the situation. In fact, at all the sites teaching and learning was conducted in a blended environment that allowed teaching and learning to continue when the technology failed or when the GDE did not respond timeously to problems related to technology. What is evident is that, despite the Harry Gwala Support Centre being available at two sites, teaching and learning is not being affected in a paperless context. The findings from this study as presented in Chapter Five and in this chapter, provide evidence that technology is being used in the classroom, however, there is no evidence that teachers are gravitating towards teaching and learning in a

paperless context. Despite the MEC's plan for Gauteng schools to operate in a paperless context, the actual situation is contrary to what is expected in a paperless environment. The above discussion bears testimony that the traditional method of teaching and learning is still prevalent and continues to dominate the classroom environment.

When learners experienced problems with their tablets, Mr Thuli indicated:

> *... we take back the devices in, we record it then we send it back to the GDE but then for the device to come back or for them collecting the devices, it becomes a problem now because now they take forever in terms of fixing the devices and bringing them back. Because we can even log a call but then it takes forever, so now it becomes a challenge because one learner has a tablet and the other doesn't have one, so that way now they have to make a plan on how they are going to work about and everything, so it becomes a challenge.*

Mr Namane added *"... learner tablets were broken this term, they were supposed to be taken for fixing, they were not. It causes a disruption that is the difference between Illungelo Secondary and us."* A learner showed his frustration when he said:

> *... they keep the one that's broken until next year. You need a tablet this year, it's broken January, need it to be fixed in January, you'll get it next year January, 12 months of no studying because your tablet is broken.*

Another learner from Illungelo Secondary School alluded to his experience:

> *... when my tablets broke last year, I actually had to wait a very long period of time... even though the school wanted my parents to pay, my parents didn't pay, so my mum ended up buying me a new tablet. A lot of this time I was waiting for my parents to pay, I couldn't do my homework and most of the time the teacher would give me demerits for homework not done because I cannot do the homework cos the textbooks are in the tablets.*

This delay in attending to problems experienced with the tablets is an obstacle to learners completing their learning tasks. From the above learner's comments, it appears as if teachers do not take note that the learner's tablet was lost or broken and consequently penalised the learner. Since a teacher or the school is unable to replace the lost or broken tablet, the responsibility lies with the parent or the GDE. In the above situation, it is the learner who is affected adversely. If a paperless classroom is supposed to operate smoothly, then support from the GDE and parents should be timeous as the delay in their response to resolving problems experienced with learners' tablets, would impede the use of technology in teaching and learning. A learner aptly described the support from the GDE in the following words "… s*ervice delivery is very poor*".

During observations of Mathematics lessons, it was evident that many learners were using the hardcopy textbook because their tablets were either lost, stolen or broken. In addition to the above problem, it is also important that the provision of tablets at the beginning of the year is timeous as Ms Mashego pointed out:

> *... when it comes to school opening because you find that we open this week then the tablet will be delivered maybe after, they will finish deliver tablet or supply tablet to class after 3 weeks and the books are there in their tablets, as we are not allowed to give learners the hardcopies, so now the teaching and learning supposed to what stuck [stop] because we are still waiting for the tablet.*

The delay in the delivery of the tablets to schools is a challenge because the textbooks are loaded on learners' tablets and without the tablets, teaching and learning cannot take place. Teachers are not allowed to hand out hardcopies of the textbook, a directive from the GDE. It would be assumed that at the beginning of the year, arrangements would have been made the previous year for the timeous delivery of the tablets so that teaching and learning would begin without any delay. If teachers were working in a "truly" paperless environment as expected by the MEC, teaching and learning would not be accomplished as a result of the delay in the delivery of the tablets.

Teachers pointed out that access to Wi-Fi is necessary for teaching and learning. However, as mentioned earlier, all four sites complained about the unavailability of Wi-Fi and thought it the sole responsibility of the GDE to provide Wi-Fi access. Conversely, Mr Namane believed that there should not only be shared responsibility between the school and the GDE concerning training but also with other aspects regarding ICTs, such as the availability of Wi-Fi:

> *... the department is slow, but internal politics at times there's too much red tape, we are very much far, very much far but if we keep on waiting, imagine we didn't have Wi-Fi for 2 years, we waited for the department for 2 years, the school could have done something, the school could have done something because the school has money.*

In Mr Namane's words "*internal politics*" as well as "*red tape"* were additional obstacles that impeded the access to Wi-Fi at his school. In his opinion, despite the school having the necessary funds to provide access to Wi-Fi, they depended upon the GDE to resolve this problem. This could possibly be one of the reasons why Illungelo Secondary School has fewer problems concerning ICTs as they do not rely on the GDE for support. Instead, all support is provided solely by the school when compared to the other two sites with established Harry Gwala Centres. Mr Namane further indicated:

> *… we have blinds, blinds are destroyed eh, the school must re-install blinds… because it is difficult to see on the board because it reflects. I have been saying this for the past two years, you can see that they don't think that if there's the sun, they don't see how difficult it would be for you to use the smartboard, to project something on the smartboard.*

Considering blinds are relatively inexpensive, the costs could have been covered from the school funds; this is the shared responsibility that Mr Namane referred to. Hence, it would be reasonable to assume that his argument of shared responsibilities is important for ICTs to be integrated successfully in teaching and learning. He added:

> *The budget again from the SGB's it's not streamlined, it's not ICT streamlined. We still buy papers, we spend a lot of the chunk of the school's money to buy papers and buy photocopying ink and we not investing in software development of question papers, software development as a school, as a department side, the external papers are still hardcopy.*

Considering that Iziphethu Secondary is a paperless school, it would be assumed that a portion of the budget would be allocated to ICT resources rather than the purchase of paper and ink for the photocopier, since in a paperless environment these expenses should not be incurred. From the above excerpt, it is obvious that the SGB (School Governing Body) from Iziphethu Secondary School, appears not to support the idea of paperless schools since funds are still being invested to purchase stationery.

Summary

This chapter discussed the major challenges that were experienced in the four cases identified as paperless schools. The discussion of these challenges indicated that the viability of teaching and learning Mathematics in a paperless classroom is questionable. Until such time that these initial challenges are resolved satisfactorily, teaching and learning will continue in a blended environment and not a paperless environment as anticipated by the MEC.

The smartboard not working, or learners' tablets broken, stolen, lost or sent in for repairs, makes teaching and learning in a paperless context an impossible task and therefore not viable. In addition, from the discussion, it is obvious that both teachers and learners require continuous training regarding the use of the selected technology since a "once-off" training session did not suffice. Teachers maintained that training should be subject-specific and that a "follow-up" should be conducted by the trainers to verify whether teachers have attained the necessary skills. It is important to identify areas where teachers' skills are lacking as well as to identify

the diverse levels of teachers' technological skills, which could be used as a baseline to plan for future training. According to some teachers, who attended the training offered by the GDE, they commented that the trainers appeared to display a lack of ICT knowledge as well as training skills.

Chapter Seven discusses Part 3 of the findings which is the viability of teaching and learning Mathematics in a paperless context.

CHAPTER SEVEN

FINDINGS AND DISCUSSION

PART 3: THE QUESTION OF VIABILITY

Introduction

This chapter draws together findings on teachers' and learners' opinions regarding the viability of teaching and learning Mathematics in a paperless classroom as it was important to establish whether the existence of teaching and learning in a paperless classroom would be sustainable in the future. These opinions originated from interviews held with Mathematics teachers, one deputy principal as well as ICT committee members, who were responsible for driving the ICT initiative at the respective sites. Classroom observations of Mathematics lessons as well as focus group discussions conducted with Mathematics learners provided valuable insight into the viability of teaching and learning in a paperless environment. The themes derived from the collected data that were analysed are as follows:

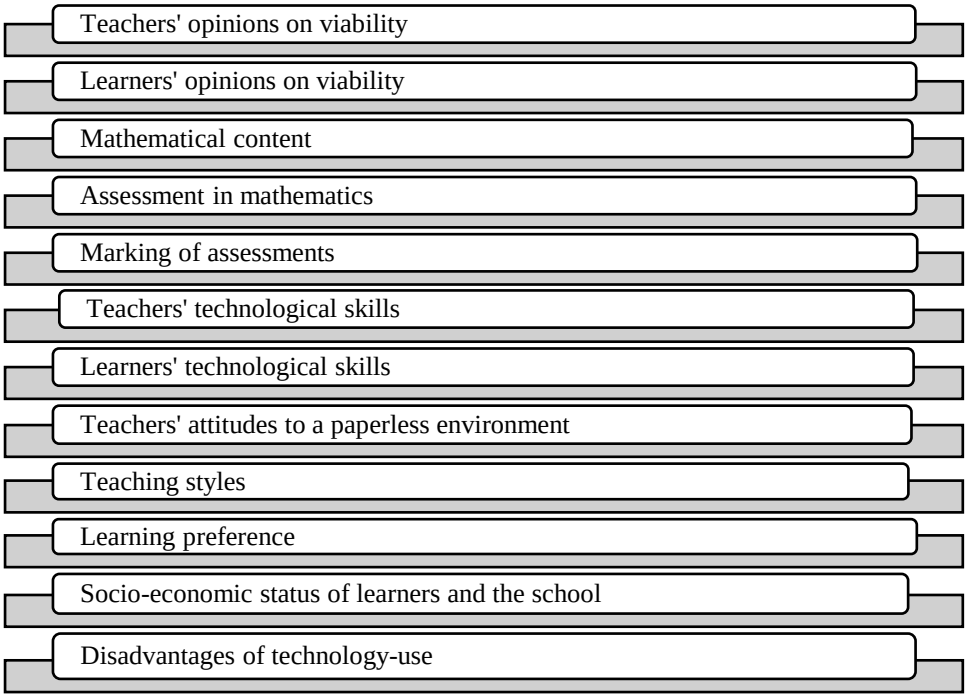

Figure 7.1 Themes on Viability

For each of the identified themes, I have presented a summary of the codes as identified in a table before the discussion of each theme. To repeat, the sub-headings in this chapter are the

actual words of the participants that portray the contents of each identified theme. The table below provides the initial open codes that were clustered to arrive at the theme "Teachers opinions on viability", followed by a discussion on this theme.

Table 7.1 Teachers' Opinions on Viability

Representative phrases from participants	Open coding	Axial coding
"I don't think we can go hundred percent paperless" (Ms Sedibe). "I think it will be impossible" (Mr Dlamini). "We cannot teach totally without paper" (Ms Mashego). "It's not possible! It's not possible without the use of paper" (Mr Khoza). "I don't know if it will, if they will ever be able to take away the paper in this school because there are so many factors regarding that" (Ms Smit). "I don't know if they will ever get it a 100% there" (Ms Smit). "I think to completely make it paperless, I think it's impossible" (Ms Smit). "Not for Mathematics. Definitely, a big no from my side" (Ms Vermaak).	Impossible/without paper. Cannot teach without paper.	Teachers' opinions on viability: teachers believe that it is not viable to teach Mathematics in a paperless environment.
"You definitely need to write" (Mr Dlamini). "You can't learn Mathematics, like only observing" (Mr Dlamini).	Need to write.	
"You need to hand in hardcopy of something" (Mr Dlamini). "You can complement them, but we can't cope, go completely without [paper]" (Mr Dlamini). "I'm not convinced that we can do without no hardcopy" (Mr Dlamini).	Hardcopy necessary, technology should complement paper/blended.	
"I see it very difficult with Maths because it is a concept you need to practice over and over and if the kids don't practice over and over, physically writing it out and doing it, then they really going to battle" (Ms Smit).	Need to practice.	
"If they take away paper, how are the kids going to write exams?" (Ms Smit)	Assessment.	

"I don't think we can go hundred percent paperless"

Ms Sedibe from Isilomo Secondary School is steadfast in her belief that teaching and learning in a hundred percent paperless classroom is not a possibility. Her opinion on the issue of viability is supported by her colleague, Mr Dlamini's excerpt below:

> *… in a Maths environment … I think it will be impossible,... you can't learn Mathematics like only observing, you need to … literally write it, unless if they type, but you know sometimes it is cumbersome to type Mathematics when you using those things [tablets] because of the symbols that you use. So sooner or later you definitely need to write …, you can complement I think ICT with hardcopies and paper… but we can't cope, go completely without [paper]. So, I'm not convinced that we can do without no hardcopy, you know the chalkboard, you know the paper. I think it's more like they need to complement each other if to actually work.*

The following words and phrases as indicated in the table above, "*impossible*", "*not possible*", "*a big no*", "*not for Mathematics*", "*cannot teach totally without paper*", unequivocally exhibit teachers' opinions that teaching and learning Mathematics in a paperless environment is not viable. Ms Smit agreed:

> *I see it very difficult with Maths because it is a concept you need to practice over and over and if the kids don't practice over and over, physically writing it out and doing it, then they really going to battle.*

The above participants are unwavering in their beliefs that it is impossible to reach the point of teaching and learning Mathematics in a paperless environment; writing on paper is essential for Mathematics because learners need to practice concepts. Although writing is possible on a tablet, Hubber et al. (2016) pointed out that because the tablet surface is smoother than paper, it is more difficult to write on a tablet than to write on paper.

However, a study conducted by Galligan, Loch, McDonald and Taylor (2010) that focused on electronic writing using tablet PCs in two University Mathematics courses revealed that 75% of the students preferred their lecturer to write on a computer and 98% of them indicated that writing during the lectures assisted them to understand the Mathematical content. Students indicated that when the lecturer used the writing function on the tablet, they could follow the steps involved when solving the problem as they were able to listen to the explanation instead of viewing PowerPoint slides that already had the solutions. Also, these lectures were saved on a CD and made available to fifteen distance education students for comment. The responses from these students were positive and they indicated that the "… *material came alive for them through voice and screen capture of solutions in action*" (Galligan et al., 2010, p. 42).

What may be inferred from the above discussion is that since teachers at these "so-called" paperless schools are accustomed to the traditional teaching method, they preferred to use this method since pen and paper have been used in teaching and learning for ages and are possibly "afraid" to incorporate the writing function which is available on tablet PCs. However, one also needs to take cognisance of the fact that none of the tablets provided to these paperless schools had any Mathematical software loaded on the tablets and learners simply used the tablet to access the textbook and other available resources, consequently, the only option was to use pen and paper. In addition, for teachers to have a positive attitude to the writing function on tablets, they need to have the necessary software as well as adequate training on how to use the

available software. Particular attention should be paid to the use of PowerPoint slides for the teaching and learning of Mathematics as in the above discussion students indicated that they preferred their lecturer to "write" since by doing this, the content became more understandable to them. As discussed in Chapter Six, PowerPoint slides were prepared and distributed to teachers from paperless schools to teach Mathematics. Similarly, it is important that Mathematics teachers do not simply read off these slides but rather ensure that they show students how to physically solve the problems by writing since learners would be able to follow the steps as the teachers writes the solution, whether on the tablet or the board.

The discussion in Chapter Six and in the next section, revealed that both teachers and learners lacked the requisite technological skills and therefore, required ongoing training tailored to the varying skill levels of the participants. Mukhari (2016, p. iv) endorsed this recommendation "*… more regular workshops, which focus on the development of ICT skills in accordance with the proficiency levels required to effect successful integration of ICTs by teachers, be conducted*". What is surprising is that it has been five years since the establishment of these "so-called" paperless schools, yet all Mathematical work is completed by learners in their exercise books and teachers and learners both do not have Mathematical software on their tablets. How then does the Gauteng MEC expect these teachers to teach and learners to learn in a paperless context?

To repeat, at Intaba Secondary School, there were no smartboards fixed to the classroom wall in any of the Mathematics classrooms; however, teachers had the smartboard software loaded on their personal tablets. Mr Thoko from this site found that the size of the tablet screen was inadequate for him to write on and consequently, preferred to write on a whiteboard (see Chapter Six). What may be inferred from the above is that if the teacher finds the tablet screen too small to write on, most probably learners could experience a similar challenge using a tablet.

Runnels and Rutson-Griffiths (2013, p. 277) concurred "*… a major constraint imposed by the use of tablet PCs is the small screen size*". Since all work is supposed to be completed electronically using a tablet in these "so-called" Gauteng paperless classrooms, it would have been wise for the DoE to have conducted sufficient research on the suitability of the tablet for teaching and learning purposes. As mentioned previously, teachers and learners should have

been included in this research to ascertain the most appropriate device to be used. Cost, portability and usability should have been some of the important features to consider when the decision was made to choose tablets to be used in paperless classrooms. Since the intention of the DoE to integrate technology in teaching and learning was to enhance the teaching and learning process, teachers must identify the affordances and the constraints that the selected technology brings to teaching and learning. However, at certain paperless schools included in this study, teachers had no choice regarding which technology to use since the DoE had already decided to implement the use of tablets. Bearing in mind the challenges as discussed in Chapter Six regarding the smartboards and the tablets, one wonders whether the DoE was not too hasty in implementing paperless classrooms.

Mr Dlamini emphasised that writing is an important aspect of Mathematics because it is difficult and "cumbersome" for learners to type the different symbols used in Mathematics on a tablet; he is therefore, of the opinion that pen and paper should not be excluded from teaching and learning. This type of teaching and learning environment that Mr Dlamini refers to, is a blended environment, where technology is integrated with the traditional teaching method (Giarla, 2017). Giarla (2017) added that blended learning is imperative as it allows for the different learning styles of learners, where teaching and learning can be customised to suit learners' individual needs. However, until recently it was generally accepted that learners learn by adopting different learning styles such as listening or hearing (auditory), while others benefit by seeing or reading the information (visual) and finally, the kinaesthetic learner who prefers to learn by carrying out physical activities. The contention is that learners do not choose their learning styles, rather it is the content that must be taught that dictates the teaching, and learning styles to be used (Hamer, 2019). For example, Mathematical content has to be taught visually as well as kinaesthetically because it will not be possible for a learner to understand construction in geometry without actually seeing the shape and using the appropriate technology, for example, a compass to draw an arc. Similarly, learners learn languages by listening (auditory). Therefore, although some learners claim that they fall into one or more of the listed categories of learning styles, while teachers claim that they adapt their presentation styles according to the learners' learning styles, this is not accurate; it is the subject content that dictates how the material should be presented. Likewise, when using technology and other teaching resources, it is important that teachers choose the appropriate resource that will assist learners to best understand the content.

Mr Khoza, a colleague of the above-mentioned participants concurred "*I don't think like at all we cannot use the paper. It's not possible! It's not possible without the use of paper"*. All the teachers from Isilomo Secondary School agreed that teaching and learning in a paperless environment is not a reality. This is endorsed by Ms Mashego's statement "*We cannot teach totally without paper*". Again, it is evident that these teachers cannot anticipate teaching and learning Mathematics in a paperless environment. However, to enhance the learning process, they share the opinion that ICTs should be integrated with the traditional method of teaching and learning. If these teachers do not foresee the possibility of a paperless classroom, what may be inferred is that a paperless classroom is not viable and instead a blended environment would be more appropriate.

Although not a Mathematics teacher, but a member of the ICT committee at Illungelo Secondary School, it would be expected that Ms Smit would advocate the use of technology for teaching and learning in a paperless context. However, her statement below indicated her honesty when she expressed her opinion regarding a paperless environment:

> *I don't know … if they will ever be able to take away the paper in this school because there are so many factors regarding that ... If they take away paper, how are the kids going to write exams? I don't know if they will ever get it a 100% there. I don't think so. Like I said it is very difficult for a school to go completely paperless, but I think to completely make it paperless, I think it's impossible*.

The fact that Ms Smit claimed that a paperless environment is impossible and that she cannot foresee the viability of a paperless environment, it makes one doubt how novice ICT users would cope in a paperless teaching and learning context. Ms Vermaak, who is from the same site as Ms Smit, is a retired Mathematics teacher. She was recalled to fill a vacant post at Illungelo Secondary School because of her excellence in teaching Mathematics. She has been teaching Mathematics for forty-seven years and is definitely not averse to the use of technology in her classroom. In fact, she was one of the two teachers from all the participants in this study who used GeoGebra to demonstrate the drawing of graphs to her learners. When questioned about the viability of teaching and learning Mathematics in a paperless environment, she was emphatic in her response "… *not for Mathematics. Definitely, a big no from my side"*. The above excerpts indicate participants' confidence that the teaching and learning of Mathematics in a paperless classroom, is not viable. They, however, emphasised the necessity of a blended environment where writing on paper is mandatory for the teaching and learning of Mathematics. As both teachers and learners are key participants in a classroom, it is essential

that learners' opinions on the viability of learning Mathematics in a paperless environment as presented in the table below, be considered as well. The comments in table 7.2 were collected from the focus discussions conducted with Mathematics learners from all four sites.

Table 7.2 Learners' Opinions on Viability

Representative phrases from participants	Open coding	Axial coding
"I think … it's not possible to be a completely paperless school". "… it's hard to be completely paperless especially in a Maths class". "… it's not possible to be completely paperless, especially a Maths class". "So, it's impossible to be a complete paperless school". "It didn't make sense to me. I was like, we were writing on a paper for seven years, how are they going to make it able [possible]?"	Impossible.	Learners' opinions on viability: learners are of the opinion that the teaching and learning of Mathematics in a paperless environment is not viable.
"… there's power failure or … learners haven't charged their tablet 100%, the teacher can make hardcopies for us".	Power failures. Hardcopies.	
"Mathematics should stay solely on paper". "… you have to do calculations somehow and you have to use it through the use of the paper". "We have to use paper somehow". "We definitely need both because especially in a Maths class it's very difficult to only use your gadget because as I mentioned earlier you have to use your paper somehow for calculations because a tablet doesn't write, it only types". "We need paper". "… we need both paper and gadgets so it's not one or the other". "We should also use paper because … you can break your tablets then you don't have anything at all, so I think that's why I think you should use paper". "You cannot teach Maths with technology. There are things you need to write them down". "If the MEC is thinking of making a completely paperless school, I would advise him not to, because we need paper".	Paper necessary. Blended. Writing on paper. Advice to MEC.	
"Honestly speaking I am against technology in Maths". "I would like to say it was not a wise idea to bring smartboards and all the technological things in this school. Some children are starting to be lazy in learning areas and others are busy failing but when you open their tablets there are many games, songs and videos, so I don't think it's a good idea".	Against technology in Maths. Learners' results. Inappropriate apps.	
"How many kids have fallen because of this experiment that is still trying to work? For that I say you can't gamble with education … somewhere else yes, this is education, our future after all".	Experiment. Gamble.	

"Mathematics should stay solely on paper"

From the table above, it is evident that learners agree with their teachers regarding the impossibility of working without pen and paper in the Mathematics classroom. The majority of the learners during the focus group discussions highlighted that pen and paper should not be removed from the classroom as indicated by the comments in the table above and the abstract below:

> *... it's hard to be completely paperless especially in a Maths class because you have to do calculations somehow and you have to use it through the use of the paper. You can't use a tablet for uhm, roughly just to calculating something so I think ... it's not possible to be a completely paperless school because we have to use paper somehow and ... at some point a teacher has to maybe make photocopies of a classwork ... it's not possible to be completely paperless, especially a Maths class.*
>
> *So, it's impossible to be a complete paperless school.*

If teachers and learners cannot foresee teaching and learning Mathematics in a paperless environment, *then on what evidence did the Gauteng MEC base his decision to implement paperless schools?* The literature cited in Chapter Three supports teachers' and learners' claims that Mathematics cannot be taught solely with the use of technology. Therefore, these sites as well as other schools should not be identified as paperless schools as teaching and learning is being conducted in a blended environment. A more appropriate name for these schools would be "ICT driven schools", as suggested by Mr Namane.

A learner demonstrated her skepticism of teaching and learning in a paperless environment:

> W*hen I heard the concept paperless schools, it didn't make sense to me. I was like, we were writing on a paper for seven years, how are they going to make it able [possible]? It didn't make sense to me like, I didn't just get the concept paperless school.*

Because learners have been using pen and paper for the major part of their school years, it may be unreasonable to expect learners to abandon these, and teachers to stop using the chalkboard/ whiteboard overnight. Any innovation should be introduced gradually to ensure that both teachers and learners adapt accordingly.

Like Mr Dlamini, a learner from one of the sites echoed his sentiments regarding the unsuitability of teaching and learning Mathematics in a paperless environment:

> We *definitely need both because especially in a Maths class it's very difficult to only use your gadget because as I mentioned earlier you have to use your paper somehow for calculations because a tablet doesn't write, it only types. So you can't type x times x, it's hard we need paper ... 100% we need paper especially if the teacher needs to give us eh classwork and then there's power failure or there's a one of the learners haven't charged their tablet 100%, the teacher can make hardcopies*

for us and it is very convenient. So, we need both paper and gadgets. So, it's not one or the other, in my opinion, we need both.

From the above learner's perspective, pen and paper, together with ICTs, should be used for teaching and learning Mathematics because she believed that the use of technology alone would not suffice. Moreover, she pointed out that the use of the tablets did not allow for the writing functionality which is a requirement for Mathematics. In addition, she referred to how a blended environment would be advantageous in cases of power failures or when learners' tablets are not charged; these were major challenges experienced at all four research sites, which have been discussed in detail in Chapter Six. As someone born in the digital era, it would be expected that she would embrace technology. However, the following statement by her speaks volumes "*If the MEC is thinking of making a completely paperless school, I would advise him not to, because we need paper".* Other reasons provided for the use of pen and paper in the classroom, are as follows:

We should also use paper because … you can break your tablets then you don't have anything at all, your things are now on the tablet are completely gone so you will have to start all over, so I think that's why I think you should use paper.

This thing of technology it confuses me … you cannot teach Maths with technology … There are things you need to write them down.

Broken, lost or stolen tablets presented a major challenge to both teachers and learners as discussed in Chapter Six. When using technology, all documents must be backed up either on the cloud or on a physical storage device. However, creating backups of electronic documents is usually neglected by computer users. In the event of the tablet being broken, lost or stolen and the learner having no backup of the documents that were saved on the tablet, this would affect the learner adversely as they would have lost all the study material and as a consequence, would not have any material to study from. This is the reason why the learner preferred the use of pen and paper [hardcopies].

As "digital natives" (see Chapter Two) it was not expected that learners would be averse to a paperless teaching and learning environment as well as the sole use of technology for teaching and learning. It was surprising to hear the honesty and passion with which they offered their opinions:

Honestly speaking I am against technology in Maths.

In my own opinion, I would like to say it was not a wise idea to bring smartboards and all technological things in this school. Some children are starting to be lazy in learning areas and others

are busy failing but when you open their tablets there are many games, songs and videos, so I don't think it's a good idea.

With the introduction of the use of smartboards and tablets in the classroom, learners indicated that technology has had a negative effect on some of their behaviour. The inappropriate use of tablets contributed to their poor performance in Mathematics. A learner pointed out:

> *It's too long and listen how many kids have fallen because of this technology thing in this school? How many kids have fallen because of this experiment that is still trying to work? For that I say you can't gamble with education … somewhere else yes, this is education, our future after all.*

This learner calls the establishment of a paperless school "an experiment" and believed that it had been detrimental. She clearly stated that the use of technology in her school has caused learners to retrogress rather than progress and believed that their futures have been "gambled" with and jeopardised.

The necessity of pen and paper and writing in Mathematics cannot be over-emphasised as both teachers and learners firmly believed that it was impossible to teach or learn in a paperless environment. The literature review in Chapter Three confirms that teachers' beliefs, as well as the subject content, influence the use of technology in the classroom. Since both teachers and learners believe that pen and paper and writing are indispensable in a Mathematics classroom, this indicates that a "truly" paperless classroom will not be viable. Apart from teachers having deep-seated reservations, learners were quite vocal regarding teaching Mathematics in a paperless classroom. Table 7.3 below summarises the participants (teachers) beliefs that teaching and learning Mathematics in a paperless context is not viable due to the subject content that dictates whether the use of technology was suitable or not.

Table 7.3 Mathematical Content

Representative phrases from participants	Open coding	Axial coding
"We cannot run away from writing… some of the topics you cannot use technology alone, you have to explain, and the paper comes in there" (Mr Sangu). "Some topics you cannot teach using technology, you should present them at least practically, do everything on the board so that learners can see the steps" (Mr Maphosa). "I think it's not possible because there's some topics that you really need to show them like graphs when you do graphs you should be able to show them how to plot the coordinates and … at least by writing on the board it will be easier for you but with some other topics at least maybe you can use this technology" (Mr Maphosa). "It's not always possible … some topics you require learners to actually measure some diagrams that are in the textbooks and obviously it is difficult to do that with a tablet because every learner will zoom in using their own [tablets]… so, ja it is difficult for learners to actually measure using that. So, in that case, you need to actually print copies to have learners to measure" (Ms Shabangu).	Subject content. Writing necessary. Blended. Not possible. Hardcopies.	Mathematical Content: all Mathematical content cannot be taught solely with the use of technology.

"Some of the topics you cannot use technology alone"

To reiterate, the MEC's statement to the press cannot be misconstrued regarding what a paperless environment entails as he clearly stated that neither exercise books, pen, paper, chalk nor the chalkboard/whiteboard would be used in the classroom. This meant that technology would be used solely for teaching and learning. However, the above sub-heading by Mr Sangu as well as teachers' excerpts in the above table provided evidence to the contrary of what the Gauteng MEC expects. If all topics in Mathematics cannot be taught with the sole use of technology, then it is obvious that the use of pen and paper becomes a necessity. Mr Sangu added "*We cannot run away from writing… some of the topics you cannot use technology alone, you have to explain, and the paper comes in there"*. The literature in Chapter Three supports the above statement and emphasises the need for the use of pen and paper for the teaching and learning of Mathematics regarding specific topics.

Mr Maphosa's statement coincided with Mr Sangu's claim "*Some topics you cannot teach using technology, you should present them at least practically, do everything on the board so that learners can see the steps. In Maths we have to show the steps"*. He supported his claim by providing an example of a topic in Mathematics, where the sole use of technology would not be suitable:

I think it's not possible because there's some topics that you really need to show them like graphs. When you do graphs you should be able to show them how to plot the coordinates and … at least by writing on the board it will be easier for you but with some other topics at least maybe you can use this technology.

Another participant, Ms Shabangu, is in agreement with the above two participants

It's not always possible hey, because … some topics you require learners to actually measure some diagrams that are in the textbooks and obviously it is difficult to do that with a tablet because every learner will zoom in using their own [tablets]… So, ja it is difficult for learners to actually measure using that. So, in that case, you need to actually print copies to have learners to measure, to have to get the same answer.

There was consensus amongst all the teachers in this study that there are many topics in the Mathematics curriculum that cannot be taught using technology only. Teachers are required to incorporate technology with the traditional method of teaching and learning (pen and paper) to teach such topics, thus questioning the viability of teaching and learning Mathematics in a paperless context. The above excerpts suggested that teachers' have the requisite PCK as they were able to ascertain that certain topics in Mathematics could not be taught exclusively with the use of technology and needed to be integrated with the traditional method of teaching and learning, where possible. In addition, they displayed TCK as they were able to identify the affordances as well as the constraints that the use of technology imposed when teaching specific Mathematical content.

To reiterate, Mr Sangu questioned whether any research was conducted before the decision to implement paperless classrooms. This was a significant question because if research had been conducted, Mathematics teachers could have provided valuable insight regarding the viability of teaching and learning in a paperless context. From the discussion thus far, evidently, teachers do not believe nor foresee Mathematics being taught in a paperless context. Once again, teachers asserted their firm belief regarding the necessity for learners to write on paper to internalise the Mathematical concepts being taught. Apart from the fact that all Mathematical content cannot be taught using technology alone, teachers are of the opinion that conducting assessments with the use of tablets, is also not possible. The table below clearly encapsulates teachers' opinions regarding assessment in Mathematics.

Table 7.4 Assessment in Mathematics

Representative phrases from participants	Open coding	Axial coding
"Writing tests or exams using the tablet is not possible" (Mr Khoza).	Not possible.	Assessment in Mathematics: assessment in Mathematics using technology does not cater for the diverse cognitive levels required according to Bloom's taxonomy.
"… because in Maths you cannot use true or false and matching and stuff like that and which is the one they have. So, we are compelled to try those, but that's not what we want, we want whereby you write, the learner writes steps you know that's what Maths involves not just answers" (Mr Thoko). "Multiple-choice or true and false, that was basically what we could do but we can't give them like a sum like solve the quadratic equation, no but then you allow them to use paper to work it out and then just from there they take the answer into the multiple-choice or true and false but still they have to use paper" (Ms Vermaak).	Question types. Writing on paper necessary.	
"… so, the papers sometimes they are needed, … because sometimes they can get into the internet, they Google, so it's cheating, that's why sometimes we need them both, we need papers, we need technology" (Mr Khoza). "… if they have tablets and we have a Wi-Fi here, ja its valuable but at the same time it concerns us because as a teacher you have to be more vigilant because those learners can Google the answers … Their formal assessments is on hardcopy" (Ms Mashego). "It's quite challenging because all learners are connected on social media, so they will be WhatsApping each other answers and there's no way to actually control that" (Ms Shabangu). "… they have access to the internet so they will cheat … you will think that learners are good while they are not good. So, the failure rate will be much big and they won't have much skills on solving" (Mr Khoza). "… learners can still open other apps using the tablet … but when it comes to test and exams, we still use paper, yes" (Mr Mbatha).	Cheating. Quality control. Assessment on paper.	
"We are still using the pen and paper for the exams" (Mr Nkosi). "I'm still using the paper-based assessment … all the assessments are still paper, are still on papers. We need to make copies, each and every time if you want to do the SBAs everything" (Ms Madi). "… they are using their notebooks … because since that they will be answering their final exams which is the national paper, I'm trying to train them to be used to those papers" (Ms Mashego). "The immediate goal, we are training these learners on how to respond to question papers in Grade 12. In Grade 12, it's on paper" (Mr Namane).	Paper necessary, Paper assessments.	
"… let's say you're writing a test on the tablet and then you mistakenly you pressed the HOME button and you leave the test going on, the mark, the answers that you've already answered are the marks you going to use as your … So that puts me in a bad spot and my parents wouldn't understand where I'm coming from … they will be like you're not learning and it's because of technology" (learner).	Disadvantage. Parental concern. Learners' results.	

"Writing tests or exams using the tablet is not possible"

Assessments are a fundamental component of teaching and learning. Teachers employ assessment as a tool to establish whether learning has taken place. In a traditional environment, assessments may be conducted either orally or in written format. At these "so-called" paperless schools, assessments are conducted using the traditional method of pen and paper. Although it is possible to use technology to conduct assessments, the only type of questions available to test Mathematical concepts at these four sites as indicated by all the teachers in this study, were multiple-choice, matching and true or false questions.

This questioning technique was found to be unsuitable for the assessment of Mathematical content as pointed out by all the teachers, who participated in this study, and in particular by Mr Thoko from Intaba Secondary School:

> *… because in Maths you cannot use true or false and matching and stuff like that and which is the one they have. So, we are compelled to try those, but that's not what we want, we want whereby you write, the learner writes steps you know that's what Maths involves not just answers.*

It is apparent from the above excerpt that Mathematics teachers are being coerced into using technology-based assessments despite teachers being aware that this method of assessment is not suitable. As a former Mathematics teacher, I concur with Mr Thoko regarding the unsuitability of the above questioning techniques to assess Mathematical content because when assessing Mathematical concepts, marks are allocated for the steps (working out) that were followed to arrive at the answer. Ms Vermaak described the steps taken by learners when they answered either multiple-choice or true or false questions in a Mathematics assessment conducted using technology:

> *Multiple-choice or true and false, that was basically what we could do but we can't give them like a sum like "solve the quadratic equation", no but then you allow them to use paper to work it out and then just from there they take the answer into the multiple-choice or true and false but still they have to use paper*.

Although learners use paper to work out the answers to the Mathematical problem, it is only the final answer that is entered in the electronic assessment, which learners would get either correct or incorrect. However, had this been a traditional assessment, learners would have received marks for the correct steps they followed to arrive at the answer, whether the final answer was correct or not. As a result, the use of multiple-choice, matching and true or false questions in a Mathematical assessment is a disadvantage to learners, as discussed above, and

once again signifies the unsuitability of using technology-based assessments. This emphasises that the traditional method of assessing Mathematical content with the use of pen and paper is essential to ascertain whether learners can employ higher-order thinking skills or not. Although technology is being used in some instances for assessment in Mathematics, it is important not to overlook the reality that all teachers in this study were opposed to this type of questioning. The above excerpts verify that despite the use of electronic assessments, learners still revert to the use of pen and paper to arrive at an answer. This illustrates that the use of pen and paper, irrespective of the context within which teaching, and learning is constructed, cannot be negated.

According to the revised Bloom's Taxonomy, there are six levels of questioning which assessors should take cognisance of when preparing assessments (see Chapter Three). These electronic assessment tools comprise only multiple-choice, matching and true or false questions, which are not adequate to assess the different cognitive levels as indicated by Bloom's Taxonomy. Until such time that appropriate software is developed to assess learners' Mathematical knowledge and skills, according to the different levels of questioning (Bloom's Taxonomy), the only option would be to conduct assessments in a blended environment. Subsequently, this exemplifies the notion that Mathematical assessments conducted in a paperless environment are not viable.

Apart from the type of questions available for assessments using technology, the issue of cheating in electronic assessments has been highlighted by several teachers. For example, Mr Khoza stated, "*So the papers sometimes they are needed… because sometimes they [learners]can get into the internet, they Google, so it's cheating, that's why sometimes we need them both, we need papers, we need technology*". Ms Mashego agreed with Mr Khoza:

> *Last year, they tried to start e-examination but with those learners if they have tablets and we have a Wi-Fi … it concerns us because as a teacher you have to be more vigilant because those learners can Google the answer… so you find that the class is full, its 55 learners I can't go up to the last learner there, so in that case it becomes disadvantageous because those learners can google answers. Their formal assessments is on hardcopy.*

Research indicates that electronic assessments do present many challenges such as cheating, plagiarism and impersonation (Mellar et al., 2018; Eljimini et al., 2012; Nicol, 2007). In a study conducted by Minty (2019) regarding the use of electronic assessments at a Higher Education Institution, it was found that students were caught cheating as they made use of the internet to

search for answers. As a result, lecturers and tutors had to be extra vigilant during electronic assessments. The above discussion supports Ms Mashego's claim that learners cheat during electronic assessments by having access to the internet. Considering that there are large numbers of learners in a class (sometimes in excess of 50), it is necessary for teachers to be extra vigilant when conducting assessments using technology. In addition to learners searching the internet for answers, they exchange answers amongst themselves using WhatsApp as pointed out by Ms Shabangu:

> *It's quite challenging because all learners are connected on social media, so they will be WhatsApping each other answers and there's no way to actually control that. So, the best way would be to say is ok, yes it's an investigation, it's open book but you are not allowed to use your tablet because we are avoiding letting learners use their tablets because if they use their tablets then they are WhatsApping each other answers.*

Mr Khoza highlighted the adverse effects of cheating:

> *… they have access to the internet so they will cheat, there will be a lot of cheating, you will think that learners are good while they are not good. So, the failure rate will be much big and they won't have much skills on solving.*

As a result of learners cheating, teachers may, unfortunately, labour under the misconception that learners have attained the necessary Mathematical skills since their results from the electronic assessments provide evidence that they have passed. Due to not having attained the requisite Mathematical skills, due to cheating whilst writing electronic assessments, Mr Khoza pointed out that the failure rate would increase. Mr Mbatha reaffirmed the challenge of cheating that teachers encountered, "… *but the challenge … we have at the moment, is that learners can still open other apps using the tablet… but when it comes to tests and exams, we still use paper, yes"*. What may be inferred from Mr Mbatha's statement is that since no software is currently available at their school to adequately conduct assessments in Mathematics, as well as cheating being a challenge, all tests and examinations are still conducted using the traditional method of pen and paper. This is precisely how assessments for Mathematics are being conducted at all the sites, which is confirmed by the following excerpts:

> *We are still using the pen and paper for the exams* (Mr Nkosi).

> *I'm still using the paper-based assessment… we don't have the assessment which are on the tablets… all the assessments are… still on papers. We need to make copies, each and every time if you want to do the SBAs everything. We need to make copies of those activities* (Ms Madi).

The above excerpts support the belief that a paperless environment to assess Mathematics is not viable. Bearing in mind that paperless schools were established in 2015 and these schools

are still using the traditional method to conduct assessments, the question arises whether there will ever be a time when the appropriate software will be available to adequately assess the Mathematical content in a "truly" paperless context. Although other schools have used electronic assessments comprising multiple-choice, matching and true or false questions, Ms Madi highlighted that at her school they did not have any electronic assessment tools on learners' tablets available for Mathematics. An additional question arises, "*Why is this the case?"* Consequently, the viability of teaching and learning, including assessment, in a paperless environment, once again becomes questionable.

Ms Mashego stated that because learners wrote their final examination on paper, she ensured that her learners wrote all assessments in Mathematics using the traditional method of assessment to prepare them for their final examinations:

> *In my classroom when they answer, they are using… their notebooks… because… they will be answering their final exams which is the national paper, I'm trying to train them to be used to those papers, because yes it's a paperless school but let us focus to the reality. The reality is on the final exam we will be using papers. They will be given question papers, the hardcopies, and then they will be answering on their papers, so … I'm training them for their final exam, I allow them to write and answer using their classwork books.*

Mr Namane accedes that because Grade 12 learners' examinations are paper-based, the use of pen and paper cannot be eliminated from teaching and learning. He claimed that technology should be used to enhance teaching and learning and not be seen as a replacement of pen and paper:

> *We are training these learners on how to respond to question papers in Grade 12. In Grade 12, it's on paper, so if we start by from Grade 8 and total use, no paper at all, they will be stunned in Grade 12 because we are re-introducing paper and they are not used to it. So that's why I'm saying it can be used to enhance but paper has to be there.*

Mr Namane's statement about preparing learners for examinations is supported by the literature in Chapter Three that teachers are reluctant to incorporate technology in teaching and learning due to the pressure of preparing learners for paper-based examinations. If learners are taught using technology only, it would be reasonable to assume that they should be assessed in the same manner. In a paperless environment, learners would lose the practical writing skills (on paper) as well as the pace required to write a paper-based examination since they would be working solely with technology. These practical writing skills, as well as the pace of completing paper-based assessments timeously, would be dependent upon continuous practice. However, in a paperless context, learners would be denied this practice as all assessments

would have been conducted electronically. Considering that the Grade 12 examinations remain paper-based, and if learners are taught in a paperless environment but assessed using a paper-based assessment, these learners would be disadvantaged since they may lack the necessary skills to answer paper-based assessments, as indicated by the data in the table, above. This lack of preparing the Grade 12 learners to answer paper-based assessments could have a negative effect on their results and exclude them from entering specific qualifications at HEIs.

The above discussion bears testimony that teachers do indeed have the requisite PK as they are knowledgeable about the appropriate methods to employ when assessing learners' Mathematical abilities. Their pedagogical knowledge informs how Mathematical content should be assessed. By identifying the constraints that the use of technology imposes when assessing Mathematical content, teachers are displaying TCK. Besides teachers' opinions on electronic assessments, a learner provided a reason why she preferred assessments not to be conducted on a tablet:

> *Let's say you're writing a test on the tablet and then you mistakenly you pressed the HOME button and you leave the test going on, the mark, the answers that you've already answered are the marks you going to use as your results and it wasn't intentional for you to leave the test in the first place. So that puts me in a bad spot and my parents wouldn't understand where I'm coming from, as to I pressed it by mistake. So, they will be like you're not learning and it's because of technology.*

In a paperless environment, assessments supposedly should be conducted using technology, therefore, teachers will be required to mark these assessments electronically. In the table below, the excerpts are from one teacher only. She focused on the challenges of marking assessments electronically as she has been marking GDE Grade 12 paper-based Mathematics papers for many years and was able to draw upon her experiences.

Table 7.5 Marking of Assessments

Representative phrases from participants	Open coding	Axial coding
"… honestly with paper, it's easier" (Ms Mbheki).	Marking not possible on the tablet.	Marking of Assessments: marking of assessments using a tablet is difficult and cumbersome when compared to paper-based assessments.
"Really, on a tablet? The teacher will be frustrated … because you have to keep switching [screens]. When its paper somehow it is a little bit easier, but to expect me to grade 35, 60-minute papers online, on the screen, no it's frustrating. If I am going to be thorough and fair, it's frustrating" (Ms Mbheki).	Teacher frustration. Large student numbers. Marking easier on paper.	

"Somehow because I've looked at, I've seen Siyabonga's work, the method looks unusual. So, I put it aside and I keep marking, while I'm also processing if there is a way, I can allow myself to think like Siyabonga so that I can approach it the way he did. Then I pick up another piece of paper, I quickly try to approach it, you know thinking like him now so that I don't score him a zero" (Ms Mbheki).	Marking style. Grade 12 marker.	

"Honestly with paper, it's easier"

The above excerpt is taken from Ms Mbheki's interview where she referred to her experience as a marker of Grade 12 final assessments:

> *Now when you look at something like analytical Geometry, I enjoy that … you have a question and sometimes by the morning of the 3rd day of marking we are looking at the 20th way of answering the same question. Really, on a tablet? The teacher will be frustrated, the teacher will be frustrated because you have to keep switching, you have to keep switching [screens]. When its paper somehow it is a little bit easier, but to expect me to grade 35, 60-minute papers online, [shakes her head negatively, to say no], on the screen, no it's frustrating. If I am going to be thorough and fair, it's frustrating. For complete fairness, that's how I mark and for me, if I have to be marking them on-screen it means that I have to keep switching, [shakes her head negatively], no, no.*

She enjoys marking paper-based assessments and explains how markers address diverse solutions that learners may provide to answer a question. When she says, "*really on a tablet?*" she is expressing the unsuitability regarding the use of a tablet to mark learners' work and is adamant that this would cause frustration among teachers, who are expected to mark assessments electronically. She explains how marking paper-based scripts gives her the opportunity and the flexibility to consider all solutions, even those that do not match the memorandum. Consequently, her marking style is to deliberate on the method used by the learner, instead of assigning a zero for that question:

> *Somehow because I've looked at, I've seen Siyabonga's work, the method looks unusual. So, I put it aside and I keep marking, while I'm also processing if there is a way, I can allow myself to think like Siyabonga so that I can approach it the way he did. Then I pick up another piece of paper, I quickly try to approach it, you know thinking like him now so that I don't score him a zero.*

Ms Mbheki indicated that marking on paper is much easier and less frustrating than marking electronically as the latter requires more effort to search for a learner's script that she would like to peruse perhaps for a second time. She indicated that when marking paper-based assessments, she can set aside the script that does not match the memorandum and continue marking while attempting to understand the method used by the learner to answer the question. When she wanted to return to the "affected" script, she believed it would be easier to locate that script since it was set aside instead of searching through an entire collection of electronic

documents on a tablet. With regards to the above scenario as described by Ms Mbheki, when marking assessments electronically, there is a possibility that the marker may forget to return to an assessment. However, when marking a paper-based assessment this omission is unlikely to occur as the script has been set aside. In this way, the teacher is ensuring objectivity so that the learner is not unfairly disadvantaged.

An article entitled "*Online Marking - Marking assignments online to improve feedback for students*", published in 2012 on the website TeachOnline.ca, provides evidence that supports Ms Mbheki's reservations towards marking Mathematics electronically. Before the online initiative, students at the University of Waterloo in Canada mailed their assignments to the Centre for Extended Learning, who in turn would organise and distribute these assignments to the respective lecturers to be marked. However, students complained that this process was lengthy and that they did not receive timeous feedback. As a consequence, they were unable to implement the feedback received to prepare adequately for subsequent work that needed to be submitted. Taking cognisance of students' complaints as discussed above, the Centre implemented online marking of assignments that replaced the paper-based system to improve the learning experience for their students, as well as to reduce costs and turnaround time regarding feedback. Students submitted their assignments directly via electronic dropboxes, while lecturers used a stylus on a tablet PC to conduct electronic marking. Some lecturers were more comfortable marking paper-based assignments, despite some of the benefits of marking assignments electronically, such as positive student reactions, reduction in paper usage, lecturers not so concerned about losing student's scripts, and lecturers' enthusiasm. Even though lecturers tried to mark assignments electronically, they found it difficult to adapt to the use of the tablet PC for this purpose. Ms Mbheki's reservations towards electronic marking of assessments in Mathematics is supported by the following:

> *In some courses, such as Mathematics, physics, and chemistry, the nature of the assignments themselves makes a shift to online marking more difficult. Handwritten assignments may be easier, especially for first-year students, than learning the complex programs necessary to insert formula electronically* (TEACHONLINE.CA, 2012).

Once again, it is apparent that the subject content will dictate the assessment method to be used; electronic or paper-based. Since in a paperless context, teachers are required to complete all teaching and learning electronically, they must possess the requisite technological skills that extend beyond basic computer literacy, to conduct both teaching and assessment.

Table 7.6 Teachers' Technological Skills

Representative phrases from participants	Open coding	Axial coding
"… we don't have adequate skills to use technology" (Ms Madi). "I can't even use [it] because it is very difficult to use those protractors, compasses on the smartboard because really I think it is time-consuming" (Ms Madi). "I don't know even know how to use it, the technology" (Ms Madi). "… us teachers we are still struggling with this technology" (Mr Maphosa). "… we are still learning because there are some other features that we don't know how to use them in the smartboard" (Mr Maphosa). "I will evaluate myself and say it's not good, definitely not. I can do what I've learned what to do and that's it" (Ms Vermaak). "I'm still learning" (Mr Nkosi). "I can say I'm in average" (Ms Mashego). "Technology completely for me it's a bit difficult, … I won't trust my technology just like that" (Ms Mbheki). "When it comes to the smartboard also the teachers some of us, they don't know when to use the smartboard, they are used to this chalkboard thing" (Maphosa).	Inadequate/ average skills. Time-consuming,	Teachers' technological skills: teachers lack the necessary technological skills to integrate technology in teaching and learning.
"… you touch a ruler it goes that way [laughs], you touch a compass it doesn't want to work with you. So, at the end of the day, it exposes you as a teacher as if you don't know. So, teachers they just avoid to use those things" (Mr Sangu). "I become embarrassed; I don't want to lie" (Ms Madi). "… they lose confidence … because now they can see that our teacher doesn't know even how to use technology" (Ms Madi).	Exposes teacher inadequacy, teacher preference. Embarrassment. Learners lose confidence in teacher's technical ability.	
"I'll say it's quite good" (Mr Dlamini). "For me, I don't think training is necessary" (Mr Khoza). "No with the technology that I am using I'm fine with it, I'm perfect with it and I don't have any problems" (Mr Bhengu). "I'm quite comfortable with the technology" (Ms Shabangu).	Competent/ technology-use. Training.	

"We don't have adequate skills to use technology"

The above sub-heading reflected Ms Madi's honesty regarding the lack of technological skills, which prevented her from incorporating technology in her Mathematics classes. Despite attending training on the use of the smartboard, she felt that she was not competent to use it for teaching and learning as is evident from the following excerpt:

> *… it becomes a problem when we go to class and you are supposed to use this technology, more especially on this topic of construction that is Geometry. I can't even use [it] because it is very difficult to use those protractors, compasses on the smartboard because really, I think it is time-consuming if you use them on the smartboard.*

What Ms Madi has referred to above, was confirmed during my observation with Mr Sangu, who is from the same site. Mr Sangu is an avid user of technology, who displayed very good

technological skills when using the smartboard. However, during the observation of his lesson, he experienced problems with the use of the protractor and the compass, tools available on the smartboard. Having the experience and the technological skills, he was able to resolve the problem, although it took some time before he could proceed with the lesson. He explained

> *… you touch a ruler it goes that way [laughs], you touch a compass it doesn't want to work with you. So, at the end of the day, it exposes you as a teacher as if you don't know. So, teachers they just avoid to use those things.*

Unlike Mr Sangu, who has exceptional technological skills to use the tools available on the smartboard and was able to solve the problem, teachers like Ms Madi, who are novice users of technology, become self-conscious and therefore, prefer not to use technology in the classroom. She described how she felt when she failed to implement technology successfully "*I become embarrassed; I don't want to lie"*. When Ms Madi was unable to use the tools, the learners in her class came to her aid. In such situations, she believed learners would lose confidence in her abilities as a teacher:

> *… they lose confidence … because now they can see that our teacher doesn't know even how to use technology, you know that if the learner can come and show you as a teacher instead of you as a teacher show a learner how to operate something, so the learner will lose confidence in me.*

Because she lacked the technological skills, she added:

> *I think the old method, the traditional one I think it was good for learners because if you are teaching using the old method the learners can be able to write and see what we are doing and understand where they are having problems. So, I don't know whether if this technology it will help, I don't know because I don't know even know how to use it, the technology.*

Ms Madi's honesty is admirable because during observations, except for Mr Sangu and Ms Vermaak, all the teachers at the four sites merely used the smartboard as a substitute for the whiteboard, even though several of them claimed to have above-average technological skills:

> *I'll say it's quite good* (Mr Dlamini).
>
> *For me, I don't think training is necessary* (Mr Khoza).
>
> *No with the technology that I am using I'm fine with it, I'm perfect with it and I don't have any problems* (Mr Bhengu).
>
> *I'm quite comfortable because I have a degree in Computer Science so I'm quite comfortable with the technology and I'm happy using it* (Ms Shabangu).

Despite teachers claiming that they were proficient with the use of technology, it was not possible to verify these technological skills since the smartboard was used as a replacement for the chalkboard/whiteboard by all the teachers listed in the above excerpts. Although Ms

Vermaak used GeoGebra in her class, the work she displayed was pre-planned, which she just projected on the smartboard. TK is a component of the TPACK framework that specifies what a teacher ought to know regarding the use of technology in the classroom. However, despite teachers claiming to have exceptional knowledge and skills to integrate technology in their lessons, I did not observe any of them optimally doing so in their lessons, except for Mr Sangu and Ms Sedibe. Both these teachers demonstrated in the lessons observed that they were able to use the tools available on the smartboard comfortably and with confidence, showing that they had the necessary technological skills to do so.

Unlike the above-mentioned teachers, the excerpts below described the inability of others to use technology optimally in teaching and learning:

> *I don't know how long it's gonna take because even us teachers we are still struggling with this technology* (Mr Maphosa).
>
> *I'm not saying we are perfect, but we are still learning because there are some other features that we don't know how to use them in the smartboard* (Mr Maphosa).
>
> *I will evaluate myself and say it's not good, definitely not. I can do what I've learned … and that's it* (Ms Vermaak).
>
> *I'm still learning … but basically if the smartboard has a problem I can manage to put in the HDMI cable and I can … work from that because textbooks are not only on the smartboard but they are also on our laptops and they are also on learners eh tablets* (Mr Nkosi).
>
> *… you must not use the smartboard as a chalkboard in the smartboard. You must be able to understand all the apps that are there … I cannot say I'm outstanding, I can say I'm in average because … there are some of the apps that I'm not good on it, meaning that I'm still need of some workshops … so that I can improve my skills. I cannot say I'm outstanding maybe I'm on average* (Ms Mashego).

The above-mentioned teachers indicated that their technological skills were lacking and required more training to upgrade their skills. As a result, the majority of the teachers use the smartboard as they would use a chalkboard/whiteboard, which clearly indicates their lack of TK. Ms Mbheki confessed that she used the smartboard as she would use a chalkboard and was comfortable using the smartboard in this manner:

> *… technology completely for me it's a bit difficult, but what I've seen is… the smartboard I can use in class. I like the fact that it is interactive. I like the fact that I can write and erase and rewrite, just like my chalkboard. Ok, I like the fact that I can, like today just now I was showing how to use a ruler. I like the fact that I can do this on my smartboard, but I think that's the only one I'm really comfortable with. On the smartboard, that is also possible but not all the time, sometimes you don't know what to press and then now you can't highlight, now you can't write on the page and I went for training for 2 consecutive years… It's not that I can't use it, you understand if I have to, uhm if I was to do a presentation, not a regular teaching class, I would be very nice and good with it, ok. But when it comes to regular teach a class of teenagers, I'd be more realistic. I won't trust my technology just like that.*

It is obvious from Ms Mbheki's excerpt that her TK is inadequate. Despite her attending training for two consecutive years, it is apparent that she had not acquired the requisite ICT skills. It is a concern that after such lengthy training, she still had minimal technological skills; she pointed out that she had the confidence to conduct PowerPoint presentations but not to use technology for teaching and learning. As the skills required to conduct a PowerPoint presentation are basic computer literacy skills, one would have expected Ms Mbheki to have progressed to a higher level of competency, considering her training. In Makwela's (2019) study, the findings revealed that teachers from one of the two sites were fully supported and had the necessary skills to integrate technology in teaching and learning. However, in the second school, a teacher had inadequate technology skills and did not receive any training to integrate technology into their discipline.

Teachers from Makwela's (2019) study, indicated that additional training, as well as support, was needed as these were some of the challenges they had experienced regarding ICT integration. The findings from Makwela's (2019) study is pertinent as this study was conducted at paperless township schools in South Africa, and supports the findings from this study that teachers lack the necessary technological skills, require additional ICT training and support. Bearing in mind that many teachers struggle with the use of technology, and not all teachers are on the same level regarding technological skills, it is doubtful whether a "truly" paperless environment would be viable in the near future. In addition, it is evident that the ICT training provided to teachers was not adequate. For teachers to develop their technological skills to where they are comfortable and confident to use technology in their classrooms, training should be a priority and on-going. However, it is not only teachers who should have the requisite skills to integrate technology in the classroom, but the learners themselves need to have above-average technology skills for teaching and learning to take place seamlessly in a paperless context. It would be unfair to expect teachers to teach learners the skills to use specific ICTs in addition to teaching the subject content as this would place an additional burden on the workload of the teacher. Therefore, the next identified theme, which is summarised in the table 7.7 below, followed by the discussion is, "learners' technological skills".

Table 7.7 Learners' Technological Skills

Representative phrases from participants	Open coding	Axial coding
"My technology skills aren't that good" (learner). "… some teachers will say to you, it's second nature for the learner, but it's not always the case. Some learners you do find when they come here, they don't know anything about their tablet … they also struggle a little bit" (Ms Smit). "They are definitely not on the same level. Some learners are advanced… there are learners who they battle with it" (Ms Smit). "They are not 100% well versed with the use of technology" (Ms Sedibe).	Inadequate skills. Technology skills vary.	
"… [Learners] most of them they are good, yes … you find that most of them will be having the knowledge on how to make use of the tablet" (Ms Sedibe). "… learners are self-taught" (Mr Mbatha). "Learners are doing very well … They just understand the technology and I think it is just part of their life. They don't have any problems" (Mr Bhengu). "… the learners knowing more about technology than us" (Ms Mbheki). "… they will be the ones knowing far much better than you" (Ms Sedibe). "… if all learners are having smartphones are exposed to technology then they would all be comfortable" (Mr Thoko). "Our learners they are very good using technology … they are excellent… they know the technology, yes they are good in technology" (Ms Madi).	Teachers' assumptions.	Learners' technological skills: learners lack the necessary technological skills to use the tablet.
"… if you think of like Mathematics as a subject, the learners itself, they must be so good with technology, as in typing in Maths on your, whatever device you using, so you have to be very good with your technology work and to be able to do that because that is going to be time-consuming" (Ms Vermaak). "… if a learner is like, not well equipped to use the technology, it's [paperless environment] not going to work" (Ms Vermaak).	Influence on teaching and learning. Time-consuming.	

"My technology skills aren't that good"

As discussed in Chapter Six there is a belief amongst teachers that today's learners are proficient regarding the use of technology, as presented below:

> *… [Learners] most of them they are good, yes … you find that most of them will be having the knowledge on how to make use of the tablet* (Ms Sedibe).
>
> *You will be shocked because we never taught learners anything to be honest. You know these learners are self-taught* (Mr Mbatha).
>
> *Learners are doing very well. I think sometimes they are having maybe far much better than us as teachers. They just understand the technology and I think it is just part of their life. They don't have any problems* (Mr Bhengu).
>
> *… the learners knowing more about technology than us* (Ms Mbheki).
>
> *Even if I will be saying today, I will have to teach them how to do something, you will be surprised finding that they will be the ones knowing far much better than you* (Ms Sedibe).
>
> *… if all learners are having smartphones are exposed to technology then they would all be comfortable* (Mr Thoko).

> *Our learners they are very good using technology, I don't want to lie about that. They are excellent when because some of the apps that I don't know on the smartboard they are the ones who are assisting me that they will say 'no ma'am let me help you' and then they will show me 'no ma'am we can get this here'. They know the technology, yes, they are good in technology* (Ms Madi).

> *… learners know technology more than what you can think of because like I said some of the things I'm being taught by learners and some of the problems that we come through are the ones that solves those problems. They do, I don't know whether to call it the necessary skills or they have the light on how to operate the gadgets* (Mr Nkosi).

This erroneous belief is because learners are adept at using their smartphones as they can download apps, YouTube videos and music as well as communicate on social media. However, what these teachers failed to realise was that being able to use a smartphone, did not imply that learners were competent to use ICTs for learning. In this regard, Ms Smit had an opposing view as she said:

> *Some teachers will say to you, it's second nature for the learner, but it's not always the case. Some learners you do find when they come here, they don't know anything about their tablet … they also struggle a little bit.*

Ms Smit advised that the assumption that technology-use is "*second nature*" to learners, is unfounded as in her experience, she discovered many learners did not have adequate technological skills and struggled to use their tablets. Ms Vermaak found that the learners she taught had various technical skills "*They are definitely not on the same level. Some learners are advanced, even better than me … they are far better than me and … there are learners who they battle with it*". The above claims are supported by learners during the focus group discussions held at the four sites; a discussion on learners' ICT competence is found in Chapter Six.

If learners lack the requisite technological skills or vary regarding their ICT skills, then teaching and learning Mathematics in a paperless context becomes a tedious task as pointed out by Ms Vermaak:

> *… if you think of like Mathematics as a subject, the learners itself, they must be so good with technology, as in typing in Maths on your, whatever device you using, so you have to be very good with your technology work and to be able to do that because that is going to be time-consuming.*

Ms Sedibe added:

> *They are not 100% well versed with the use of technology. You might find them taking long to complete whereas if they are given exercise books to write their work, they do it in time.*

Both Ms Vermaak and Ms Sedibe stated that time is lost during the lessons when learners struggle to use technology. Although there may be a few learners who can use technology successfully, there are a number of them who would do better using exercise books. If teaching and learning is supposed to take place in a paperless context, learners' technological skills are key for both teaching and learning to be effortless. Additionally, if teachers have to spend time teaching learners how to use the provided technology, then time would be taken away from teaching the subject content, which could result in the teacher failing to complete the curriculum. This is evident in the following finding from Makwela's study (2019, p. 126) "*They take much time teaching learners how to use tablets effectively in learning, by the time they come to [the] content it would already be late*".

Makwela's (2019) use of the words "*it would already be late*", is in reference to the time remaining in the allotted period to teach the lesson planned for that day. Because of learners' lack of technological skills, the teacher ran out of time to teach the content because they had to show/teach some learners how to use the technological device. In such a scenario, it would not be uncommon for the teacher to perceive the use of technology negatively and consequently, they may prefer not to use technology in their classrooms. Considering Ms Vermaak's extensive teaching experience in Mathematics, the following statement that she made regarding a paperless environment, is most relevant "*... if a learner is like, not well equipped to use the technology, it's [paperless environment] not going to work"*. In addition to both teachers and learners having the necessary skills to use the provided technology, the literature in Chapter Three asserts that teacher's attitudes are central to their decision to integrate ICTs in their classrooms. Therefore, the next theme "Teachers' attitudes to a paperless environment" are presented. Before the discussion, once again the analysed data are presented in a table format for ease of reference.

Table 7.8 Teachers' Attitudes to a Paperless Environment

Representative phrases from participants	Open coding	Axial coding
"… they were very resistant to change" (Mr Mbatha). "… some of our teachers were very reluctant, we had to push very hard for them to get on board. You know some of our older teachers said: "no, they'd rather resign" (Ms Smit).	Resistant to change. Age/attitude.	Teachers' attitudes to a paperless environment: teachers' attitudes varied regarding the integration of technology in the teaching and learning of Mathematics, however, there was consensus among most teachers that Mathematics cannot be taught in a paperless environment.
"We had challenges and especially the Maths Department was our biggest challenge because … they still believe in the old traditional ways of presenting their lessons, chalk and board. So, they still wanted to stick to that method" (Mr Mbatha).	Teacher preference/ belief.	
"… we had to force them, but also what then happened is that when Matthew Goniwe started paying us for designing those lessons, as soon as the first money went into the bank, I have never seen people working so hard after that" (Mr Mbatha).	Remuneration / motivation.	
"Another issue is the attitude, some educators are not entirely familiar, it's not necessarily the old educators per se, but it's also the background of the educators that we have because as diverse as we are, one of the things that, the social background or the educational background that we come from, how exposed were we to gadgets and computers, so even surprisingly I've discovered even in my school even the more younger educators some of them are not so keen as to use the ICT resources." (Mr Namane)	Teacher attitude. Age, Background.	

"They were very resistant to change"

The above sub-heading described the attitudes of Mathematics teachers at Illungelo Secondary School, who were initially averse to teaching Mathematics using technology as pointed out by Mr Mbatha "*We had challenges and especially the Maths Department was our biggest challenge because … they still believe in the old traditional ways of presenting their lessons, chalk and board. So, they still wanted to stick to that method".* These teachers were reluctant to incorporate technology in the teaching and learning of Mathematics because they believed that Mathematics was best taught using the traditional method of the chalkboard/whiteboard as well as the use of pen and paper. In addition, they perceived the use of technology to present their lessons as an increase in their workload and therefore, preferred to use the traditional method. However, according to Mr Mbatha, once they were offered a monetary incentive by the GDE to prepare Mathematics lessons to be used by other Mathematics teachers from paperless schools, it appeared as if their attitudes changed:

> … we had to force them, but also what then happened is that when Matthew Goniwe started paying us for designing those lessons, as soon as the first money went into the bank, I have never seen people working so hard after that. It was a good motivation for most of the people because even those that were thinking that we were giving them extra work in terms of what they had to do, but as soon as they started getting the money it was a good motivation for them.

What is disturbing is that the very same teachers who preferred to teach Mathematics using the traditional method of teaching and learning as well as who complained about the extra workload were quite happy to use technology in the classroom once they were offered this monetary incentive. The following question therefore arises "*Did the monetary incentive change their belief about using technology to teach Mathematics*?" If this is so, then technology integration by these teachers are being implemented for the incorrect reasons. The use of technology in teaching and learning should have been based on the affordances that the chosen technology offered rather than the monetary incentive.

Attitude plays an important role in the way teachers approach change. The change that teachers were confronted with is the incorporation of technology for teaching and learning. This is where Fullan's (2000) statement (Chapter Three) on how individuals react to change is pertinent. Teachers' attitudes towards changing from the traditional method of teaching to the incorporation of technology elicited varied responses. For example, Mr Namane stated:

> *Another issue is the attitude, some educators are not entirely familiar, it's not necessarily the old educators per se, but it's also the background of the educators that we have because as diverse as we are, one of the things that, the social background or the educational background that we come from, how exposed were we to gadgets and computers, so even surprisingly I've discovered even in my school even the more younger educators some of them are not so keen as to use the ICT resources.*

The results of a study conducted by Minty (2011) at selected Gauteng schools regarding the integration of ICTs in the teaching and learning of Mathematical Literacy, revealed that age was an important factor that influenced the use of ICTs. It was the younger teachers who had been exposed to technology-use during their studies that were prone to using technology in the classroom, while the older teachers indicated they lacked the confidence to use ICTs. However, from the above excerpt and in Mr Namane's experience, it is evident that at his school even the young teachers were not keen to use ICTs. He attributed this attitude that teachers displayed to their educational background as is evident in Ms Madi's statement; "*While we were training to become teachers, we were not trained to use technology, we were trained to use chalkboard and duster and so forth and textbooks"*. In view of the diverse educational backgrounds of

teachers as well as the challenges experienced regarding the use of technology in the classroom, it is not surprising that teachers revert to the use of the traditional method of teaching and learning. However, in situations where the technology is in working order and there is adequate support, teachers' initial resistance to technology-use, diminished as is evident in the excerpt below by Ms Smit,

> *... some of our teachers were very reluctant, we had to push very hard for them to get on board. You know some of our older teachers said: "no, they'd rather resign". So, you know, they were very adamant about it, but you know once they've actually seen that it is making their life a little bit easier, they actually came on board very quickly.*

The above excerpt bears testimony that if teachers are supported, can see the benefits of using technology and have the requisite technological skills, just to name a few, they would be more enthusiastic and positive towards ICT integration. However, ICT integration should not be misconstrued with teaching and learning in a paperless context. ICT integration is dependent on teachers' choice of when and how to integrate technology to teach the subject content based on the affordances and constraints that technology, offers. In a paperless environment, the teacher does not have any choice but to use technology solely for teaching and learning, despite the constraints that the use of technology may pose. Therefore, if the aim is to enhance the learning experience for learners, a blended environment would be more suitable as indicated by most of the participants in this study, since teachers would not be coerced to use technology. Besides teachers' attitudes being a significant contributory factor to the non-viability of teaching and learning in a paperless environment, the method that they choose to present the Mathematical content is just as important. The question of whether their teaching styles changed or not when they incorporated technology in the classroom, was posed to the teachers in this study. Table 7.9 below presents phrases from the data collected and which were used in the discussion of the theme "Teaching Styles".

Table 7.9 Teaching Styles

Representative phrases from participants	Open coding	Axial coding
"… my teaching style … is modelled by the learners that I teach" (Mr Museba). "… you know my teaching style is basically not modelled along technology or lack of it. It is actually modelled by the learners that I teach" (Mr Museba). "I wouldn't say that technology changes my teaching style, rather it's my learners, the type of learners that I have that changes my teaching style" (Mr Thoko). "… no, it hasn't changed" (Mr Bhengu). "I cannot say it's changed. It doesn't change because what I'm presenting it's the same thing" (Ms Mashego). "The style of teaching, I won't say so" (Ms Vermaak). "I would say it hasn't changed that much" (Mr Sangu). "I wouldn't say there was much change" (Ms Sedibe).	Teaching styles unchanged.	Teaching Styles: Some teachers claimed that their teaching styles did not change when technology was integrated while others stated that their teaching styles changed slightly. In addition, some teachers maintained that their teaching styles were influenced by the learners that they taught.
"… they change a lot because … there are lessons on the smartboard, so you need to follow their way, their teaching style not considering the learner that we have in class" (Ms Madi).	Teaching style changed.	
"… the technology does not … substitute your teaching style but the technology enhances what you have been doing" (Mr Mbatha).	Advantage.	
"… now I can stand anywhere where I want and teach using that whiteboard …but now the learners are saying we are no longer seeing our teacher because we learn by seeing you in front there explaining to us… we had problems, complaints from parents now because the marks for learners were now going down" (Mr Mdluli).	Parents' complaints. Learners' results.	

"My teaching style … is modelled by the learners that I teach"

The above sub-heading is taken from the statement below by Mr Museba regarding his teaching style when incorporating the use of technology in the teaching and learning of Mathematics:

> *… my teaching style is basically not modelled along technology or lack of it. It is actually modelled by the learners that I teach. So, when I came to this school for instance from where I'm coming from, I noticed that learners seem to be happy with technology. I tried to use the old school and I noticed some would remark, why not use… So basically, my teaching approach has been sort of adjusted by the learners that I'm teaching, my style of teaching has been re-modelled.*

Mr Thoko shared this view "*I wouldn't say that technology changes my teaching style, rather it's my learners, the type of learners that I have that changes my teaching style, not the technology really because the technology is like any other media of delivery"*. These were the only two teachers who indicated that their teaching style was based on the type of learners they had in their classrooms, while some teachers indicated that their teaching styles did not change at all while others indicated that there was a slight change when technology was used. This is evident in the excerpts that follow:

> *I would say it hasn't changed that much* (Mr Sangu).
>
> *… the technology does not actually … substitute your teaching style but the technology enhances what you have been doing* (Mr Mbatha).
>
> *No, it hasn't changed because, like there are many teaching styles that you can use to maybe to try and cater for all the learners so the teaching style that I was using before the introduction of technology and after it's just the same I think, it hasn't changed, it's still the same* (Mr Bhengu).
>
> *I wouldn't say there was much change* (Ms Sedibe).
>
> *I cannot say it's changed. It doesn't change because what I'm presenting it's the same thing* (Ms Mashego).
>
> *The style of teaching, I won't say so* (Ms Vermaak).

It is important to note that teachers need to use different teaching styles in the classroom for learning to take place, since some learners might excel while others might be much slower at grasping the concepts being taught. The teaching styles used by a teacher may be influenced by their philosophical stance , the mission statement of the school but most importantly, it is the subject content, that is; what is the topic, how complex is the topic as well as the level of learners' skills that ultimately informs the method used. Thornton (2013), a Professor at Springfield Technical Community College, claimed that there are three teaching styles; these are **Direct** (tell the learners what to do), **Discuss** (ask questions and listen) and **Delegate** (empower learners) and that no style is better than the other. He adds that teachers who use a variety of teaching styles which is dependent upon many factors, one of them being the subject content that they intend to teach, are usually the most effective because when teachers vary their teaching styles they encourage and inspire their learners to achieve better results (Thornton, 2013). Taking into account this discussion, *how then does the DoE expect teachers to use lesson plans prepared by someone else?* Ms Madi expressed her concern regarding the already prepared lesson plans and being "forced" to follow them:

> *There are lessons on the smartboard, so you need to follow their way, their teaching style not considering the learner that we have in class because… if you can follow the style that they are using on the smartboard some of the learners they even have the learning, the language barrier they don't even understand the English to start with, so I need to explain on their own language. I think they did not consider the learners that we have.*

This is the reality that is faced by many teachers at South African schools who teach learners where English is their second language. Because learners are not fluent in English, teachers resort to the use of other languages in the classroom to explain concepts to learners for teaching and learning to be effective. Despite some teachers being in favour of the already prepared

lessons as it saves them lesson preparation time, Ms Mbheki just like Ms Madi voiced her objection *"Like now I'm teaching trigonometry in Grade 10, I don't want any lesson prep. I want to discuss it in class …when I'm introducing a new topic for me it's important, and then I work with my learners"*. What may be inferred from the above discussion is that these two teachers, who feel constrained by the prepared lesson plans provided by the GDE, would rather use their preferred teaching method which is either dependent upon the type of learners, their favoured teaching style or both.

Mr Mdluli illustrated how both learners and parents complained when his teaching style changed when using the tablet. This allowed him to stand anywhere in the classroom, whilst in the traditional method of teaching and learning, he was expected to stand in front of the class to write on the chalkboard:

> *We had complaints from parents … because now I can stand anywhere where I want and teach using that whiteboard, writing on my tablet there. But now the learners are saying 'we are no longer seeing our teacher because we learn by seeing you in front there explaining to us'… we had problems, complaints from parents now because the marks for learners were now going down. So, it was difficult for learners to really adjust to the system.*

Considering that learners are expected in a paperless context to complete their work on a tablet without the use of pen and paper, it was important to investigate learners' preferences regarding the use of technology versus the traditional method of teaching and learning of Mathematics. The table below contains the excerpts from the focus group discussions with Mathematics learners, delineating the open codes identified and the resulting theme which is "Learning Preference: Technology vs. paper-based environment".

Table 7.10 Learning Preference: Technology vs. Paper-based

Representative phrases from participants	Open coding	Axial coding
"… when you write something, you remember it". "… the more you write it the more you remember it".	Learning method/writing.	Learning Preference: learners maintained that they preferred to learn Mathematics using pen and paper.
"… so, it boils back again to people being different cos to you it might work that way, ok, if you write something down you remember. For me I have to look at it, say, look at it, say it and then I remember".	Learning method/ memorising.	
"… for term one, I used my tablet, just my tablet because I mean come on guys, I mean a tablet and then I got a really bad mark".	Learners' results.	
"Some learners find it easy to study from the tablet, other learners really battle to study from the tablets … you get those different learners that study differently".	Study methods.	

"I feel like paperless classrooms sometimes the educators, the teachers they neglect their duties. They think it's up to the student to figure it out or to complete the activity on their own and that's not right because some learners have different ways of learning and some people can't cope but sometimes the educators just leave them to do their own thing". "… but then it's not working. They [teachers] don't explain further, more than they would do when they [are] using papers". "… and they don't explain". "… old method like ma'am like they explained more". "… when it comes to teaching ma'am, teachers do not explain a lot, they'll just tell us to download the notes and just write them at home ma'am".	Learners' preference/ traditional presentation.	

"When you write something, you remember it"

The majority of learners from the focus group discussions preferred to write in their exercise books instead of using a tablet since they believed that "… *the more you write it, the more you remember it"*. However, this sentiment was not shared by all learners since they study differently as indicated by a learner from Illungelo Secondary School "*…it boils back again to people being different [because] to you it might work that way… if you write something down you remember. For me I have to look at it … say it and then I remember".* Another learner from the same site, expressed her experience when she only used her tablet to study for Mathematics:

> *… for term one, I used my tablet, just my tablet … and then I got a really bad mark [laughs]… when I stopped using my tablet and actually started using paper because … with paper guys, you get to visually see what is happening in the paper, which is important when you are doing Mathematics.*

The excerpts presented in this section provide evidence of learners' preferences regarding the learning context for Mathematics, which is either the use of pen and paper or the sole use of technology or both (blended). Taking into consideration learners' preferences for the teaching and learning environment, it may be assumed that in a paperless context, the learner who prefers to study using technology, may possibly perform better than the one who prefers to write on paper. Furthermore, the learner who prefers to write on paper would be placed at a disadvantage in a paperless environment since the use of pen and paper is excluded in such a context. It is therefore important that teachers take cognisance of these diverse preferences of learners and choose the appropriate method and resource that will best deliver the content. Ms Smit cautioned:

> *Some learners find it easy to study from the tablet, other learners really battle to study from the tablets … you get those different learners that study differently, and I also think that, that is a major impact that needs to consider that they really don't do at the moment… our teachers must be careful not to leave the slower learners behind as you know the technology is quite fast and they, you can almost like run through the work but you must be so careful leaving those ones behind.*

Bearing in mind that in a paperless classroom, technology is used exclusively, what happens then to those learners who prefer not to use technology to learn Mathematics? In addition, some learners voiced their disapproval regarding the use of technology in teaching and learning:

> *I feel like paperless classrooms sometimes the educators, the teachers they neglect their duties. They think it's up to the student to figure it out or to complete the activity on their own and that's not right because some learners have different ways of learning and some people can't cope but sometimes the educators just leave them to do their own thing.*
>
> *... but then it's not working. They [teachers] don't explain further, more than they would do when they [are] using papers.*
>
> *... and they don't explain.*
>
> *... the old method like ma'am like they explained more.*
>
> *... when it comes to teaching ma'am, teachers do not explain a lot, they'll just tell us to download the notes and just write them at home ma'am.*

A significant issue that was raised by learners is that teachers do not explain concepts as they did when using the traditional method of teaching and learning. One learner went so far as to say that technology is making teachers lazy and as a consequence, they preferred the traditional method of teaching and learning. Although technology is currently the "buzz word" of the 21st century and every facet of society is employing technology for a variety of reasons, one needs to take cognisance of the socio-economic factors of both the school and the learners because once tablets are acquired, further costs may be incurred regarding maintenance.

Table 7.11 Socio-Economic Status of Learners and Schools

Representative phrases from participants	Open coding	Axial coding
"… sometimes parents will want to, but they can't afford" (Mr Namane). "If they think about doing it on the tablets, then every single child in this country must have a tablet and that's quite a difficult … some of our kids have broken tablets or the parent couldn't afford to buy a tablet. So … if the school cannot make an arrangement for that child, that child sits without a tablet and it creates a problem" (Ms Smit). "Maybe for those people who are privileged it could move fast. The socio-economic thing, aspects, like from poor families, rural areas, you see" (Mr Bhengu). "… there's some of us cannot afford to pay for data" (learner). "Some kids come from the family where … they don't have electricity and then they'll say: no, my tablet was off because I didn't have this and this" (Mr Dlamini).	Lack of finance. Unequal opportunities.	Socio-economic status of learners and schools: lack of finance and unequal opportunities of learners as well as the schools negatively influence the use of technology.
"Illungelo Secondary, they pay school fees so they have a larger pool of budget, so at the end of the month they can raise something like two million, or five million in excess excluding the government subsidy" (Mr Namane).	Type of school/financially affluent.	

"… if at home if there is a negative attitude with ICT, even if you say buy this, they don't see the need, and it has to be affordable" (Mr Namane). "Remember if a parent doesn't see the need … they will tell you "I don't want this tablet"… the type of parents that we have due to their socio-economic [situation] they will [not] see any role that the tablet will play in the education of their child" (Mr Namane).	Parent attitude/financial status.	

"Sometimes parents will want to, but they can't afford"

These are the words of Mr Namane regarding the socio-economic status of learners at his school. He expressed "…*if at home, if there is a negative attitude with ICT, even if you say buy this, they don't see the need, and it has to be affordable if we say parents must buy such for the learners"*. Mr Namane addresses two issues in the above excerpt, the first being that parents have to be "on board" regarding the use of ICTs in schools, and that parents must be enlightened concerning the value of using ICTs. If parents do not see the value for their child's education, they will not purchase any ICT or device when they do not perceive these as being a necessity (see discussion in Chapter Three on parent's involvement with learning). Ms Mashego, therefore, advises that:

> *… the GDE need to … orientate, … the learners and the parents because some of parents especially in the township they don't even understand what is going on there, on those tablets. I think the GDE needs to … orientate parents first. They should conduct workshops with parents and learners, especially those who are from primary schools and those who are from rural areas*.

Studies conducted by both Mukhari (2016) and Shunmugam (2016) at selected South African schools highlight the necessity to "involve" parents regarding ICT integration in teaching and learning (see discussion in Chapter Three). This study elicited the same findings that for the succesful integration of technology in teaching and learning it is imperative that parents "buy-into" this idea of tablet-use by their children for learning purposes; if not, then learning may be thwarted by learners' parents.

The second issue that Mr Namane referred to, was the cost of an ICT device. He is of the opinion that these should not be expensive so that parents may be able to pay for these if the need arose. Bearing in mind that parents and learners sign a document when they receive the tablet, agreeing that if lost or stolen, it will be replaced; consequently, support from learners' parents inadvertently contributes to the viability of teaching and learning in a paperless context. If a learner does not replace a lost tablet as soon as possible, they will be at a disadvantage as they will not be able to study nor complete any of the necessary tasks. Ms Smit concurred:

> *If they think about doing it on the tablets, then every single child in this country must have a tablet and that's quite a difficult, you know we sit with the situation where some of our kids have broken tablets or the parent couldn't afford to buy a tablet. So, you know if the school cannot make an arrangement for that child, that child sits without a tablet and it creates a problem.*

Mr Namane in his interview, drew attention to the socio-economic status of learners in a school. The school that he referred to, was one of the schools who benefitted from the apartheid era in South Africa. During this period children of different races were exposed to unequal education opportunities; schools in urban areas were equipped with much better facilities than those in rural areas. He indicated that if parents are financially stable, then the school:

> *… can use that to fund the ICT and whenever they gonna fundraise, the parents … are keen to pay, easy to say, as learners, eh you can buy this software, the software is available, the school will subsidise, your parents will pay half, they will be able to buy… because most of their parents, most of the middle-class parents, all of them come into play. Remember if a parent doesn't see the need … they will tell you 'I don't want this tablet'… the type of parents that we have due to their socio-economic [situation] they will [not] see any role that the tablet will play in the education of their child.*

Many teachers in this study acquiesced with Ms Smit and Mr Namane regarding the socio-economic status of learners being a concern with using ICTs in the classroom, and subsequently to teaching and learning in a paperless context. Mr Bhengu added "… *maybe for those people who are privileged it could move fast. The socio-economic thing, aspects, like from poor families, rural areas, you see".*

Due to the diverse socio-economic groups in South Africa, parents can choose to send their children to either historically white ex-Model C schools or private schools. These middle-class parents may be able to afford purchasing tablets if required. However, parents from the lower-income groups have very little choice but to send their children to non-fee-paying schools. Considering that Iziphethu Secondary and Isilomo Secondary are non-fee-paying schools, Illungelo Secondary, an historically White Model C School, and Intaba Secondary, a private school, the socio-economic status of parents differs. Mr Namane referred to the financial status of a fee-paying school as opposed to non-fee paying schools "*Illungelo Secondary, they pay school fees so they have a larger pool of budget, so at the end of the month they can raise something like two million, or five million in excess, excluding the government subsidy*". What may be inferred from the statement above is that because the parents from this school pay school fees, the school can budget for ICTs since they have access to additional funds.

However, because the non-fee-paying schools depend entirely upon the Government's financial support, they do not have the additional funds that fee-paying schools have. When tablets are lost or stolen it may be assumed that learners' parents from the fee-paying schools are in a better financial position to replace or have the tablet repaired. Taking into account that parents in these non-fee paying schools may not support the use of ICTs as well as not being financially able to replace lost or stolen tablets, teaching and learning in a paperless environment may not be viable as Mr Namane pointed out that "… *parents are a very important stakeholder in the child's education, whether we like [it] or not"*.

A learner added, "*If you want to download previous Maths question papers, you need to access internet connection, therefore it is not easy for every learner, there's some of us cannot afford to pay for data"*. Considering that Wi-Fi access has been a challenge experienced at all four sites, learners, who do not have the financial means to pay for data to download question papers, may be placed at a disadvantage compared to those from more affluent backgrounds. Some schools provide learners with hardcopies of past examination papers; however, other schools instruct learners to download these papers from the internet. Not having access to the internet at home nor Wi-Fi at schools, these learners are disadvantaged, possibly leading to their poor performance in assessments, which may be attributed to their inability to access past examination papers or additional resources.

In Chapter Six, the issue of electricity being a challenge was dealt with from the perspective of load-shedding and power outages, but in this chapter, I focus on the non-availability of electricity in many learners' homes, specifically in informal settlements as a result of the socio-economic status of the parents. Mr Dlamini affirmed:

> *I normally will write my sums on the board you know and then because some kids come from the family where … they don't have electricity and then they'll say, no, my tablet was off because I didn't have this and this.*

An added issue affecting the viability of teaching and learning in a paperless environment is the constraints that technology integration imposes on both the teacher and the learner. A summary of the disadvantages of using technology in the classroom as provided by both teachers and learners is provided in the table below, followed by a discussion on the theme "Disadvantages of technology-use".

Table 7.12 Disadvantages of Technology-Use

Representative phrases from participants	Open coding	Axial coding
"… it's a total distraction to students" (learner). "… it was a distraction to me because I was busy checking at the time and when it's off, I see the reflection of me. So, I was there just fixing myself … instead of focusing on ma'am whereas if we were using a hardcopy textbook there wouldn't be any distractions" (learner). "… if we not using paper we are not going to focus in class and the computer will always be distracting us" (learner). "… technology is good but bad … it's bad especially in the Mathematics class, we can't focus, it's horrible and temptations" (learner).	Distraction, Loss of focus.	Disadvantages of technology-use: technology-use in the classroom poses various challenges that have a negative influence on teaching and learning.
"… they like taking photos of what you did on the board, which is good but you know in Maths when you are even writing, you are learning so sometimes they even forget that they have the stuff, in their tablets" (Mr Thoko). "So whenever … I don't understand I can't raise my hands anymore and say, 'Ma'am I don't understand'. I'm like 'nah, I'll google it at home' and at the end of the day I forget" (learner).	Disadvantage/ learners' forgetfulness.	
"There is an app called yHomework … The app is for Maths and that app is … it's not actually helping them; it's giving them answers instead of them practicing Maths … you need to practice every day but they keep on researching and downloading apps that help them" (learner).	Mathematical Apps.	
"… you put a formula there, then it give you all the answers. All you do is you just write all the answers down and you pass but you don't know how to do it if they remove the app, so you'll fail" (learner). "I used the app joh, my marks just dropped … I stopped using the app ne, then term 3 my marks just went high" (learner). "… it was an open book test. We all shared the Photomaths. All of us didn't achieve what we were expecting, so uh-uh it doesn't work" (learner).	Learners' results.	
"You would press the delete button on your tablet and then all the work is gone, whereas on paper you can write everything down and it wouldn't disappear as quick as pressing the delete button" (learner).	Disadvantage.	
"I feel like this paperless school would kind of take away teachers, I mean like soon we won't be having teachers and we would be learning on technology … and it's very difficult to answer, ask questions" (learner). "… if you go to paperless most teachers lose their jobs because there won't be a need for them to teach" (learner). "… the technology, we have that for extra for you, but it can't substitute me" (Ms Vermaak).	Misnomer.	

"It's a total distraction to students"

The majority of the participants, both teachers and learners, suggested that the use of the tablet in the classroom distracted learners during teaching and learning, which is confirmed by the following excerpts:

She was busy teaching there and my tablet was opened though here. Even though we were not using them, but it was a distraction to me because I was busy checking at the time and when it's off, I see the reflection of me. So I was there just fixing myself, looking at how I look instead of focusing on ma'am whereas if we were using a hardcopy textbook there wouldn't be any distractions like a notification coming on like 'wow, it's time to do this and this' since we base our lives on our tablets.

I agree with paper because if we not using paper we are not going to focus in class and the computer will always be distracting us.

Technology is good but bad … it's bad especially in the Mathematics class, we can't focus, it's horrible and temptations.

A learner, who fervently advocated for the use of technology in the classroom, responded to the issue of technology distracting learners as follows:

If you have the purpose for what you basically gonna use it then you shouldn't get distracted. I mean, if you're in the middle of reading a novel then a notification comes, you can ignore it. You have a purpose, so you shouldn't be distracted by minor things or taken away or carried away, I mean its technology it's supposed to make life easier, not complicated.

What this learner verbalised is significant as learners need to understand that they are accountable for their behaviour, therefore, they should behave responsibly when in class. This means that they need to learn to disregard all distractions so that they can learn. However, this is not the case because all the teachers and most of the learners from the focus group discussions confirmed that learners behave irresponsibly and do not use the tablets for the intended use of education. Instead, to re-emphasise learners use social media, play music and watch videos, which I refer to as the inappropriate use of technology. This was discussed in detail in Chapter Six.

The over-reliance on the tablet by learners has an adverse impact on both learning and behaviour. Learners use the tablets to take photographs of work on the smartboard to refer to later; however, they forget, according to Mr Thoko:

They use tablets and the challenge we have is normally when you take the learners notebook I get worried a bit because they like taking photos of what you did on the board, which is good but you know in Maths when you are even writing, you are learning so sometimes they even forget that they have the stuff in their tablets.

The excerpt below illustrates another situation where a learner's behaviour negatively impacts learning:

So, whenever ma'am raises something, and I don't understand I can't raise my hands anymore and say, 'Ma'am I don't understand'. I'm like 'nah, I'll google it at home' [other learners in the group agreed with him] and at the end of the day I forget because I'm human after all. So, there's no learning at the end of the day in that class.

The above learner admitted that he forgot to "google" for clarity when he arrived home; this illustrates how learners' behaviour may adversely affect teaching and learning in a paperless context. During the focus group discussions, learners alluded to how the use of specific Mathematics apps such as yHomework and PhotoMaths negatively affected learners' Mathematics results:

> *What I've also noticed lately is that there is an app called yHomework, which I saw one of my friends using. The app is for Maths and that app … it's not actually helping them. It's giving them answers instead of them practicing Maths. They depend on those kinds of apps and it's not the right way. Maths it's for practice, you need to practice every day, but they keep on researching and downloading apps that help them. Those apps should help them, should give them instructions on how to solve equations, but those apps just give out answers.*
>
> *… these apps ne they damage your brain because if you put a formula there in your tablet, then it will just come out with the answers. Yes, it does but some of the answers you will just see 6 and you'll ask yourself where does this 6 come from? You don't know, but the teacher will tell you, where the 6 comes from, the technology doesn't. So, it damage[s] your brain … I used the app joh, my marks just dropped. Like I don't know what happened, but they dropped. Then term 3, I stopped using the app ne, then term 3 my marks just went high.*
>
> *… you put a formula there then it give you all the answers, all you do is you just write all the answers down and you pass but you don't know how to do it if they remove the app, so you'll fail.*
>
> *This year, first time we once used it, was an open book test. We all shared the PhotoMaths. All of us didn't achieve what we were expecting, so uh-uh it doesn't work.*
>
> *Maybe in an instance, you would press the delete button on your tablet and then all the work is gone, whereas on paper you can write everything down and it wouldn't disappear as quick as pressing the delete button.*

The above excerpts refer to the different Mathematical apps that learners use to solve Mathematical problems. When learners refer to "just getting the answer" from the app, it could refer to the final answer, alternatively, it could refer to the complete solution to the problem indicating the steps used to arrive at the answer. By learners merely copying the answer or solution to the problem, it is not apparent whether the learner understands how to solve the problem or not. This is where the human factor comes into play. When using the traditional method of teaching and learning as expressed above by learners, teachers write the solution on the board, learners can follow each step of the solution and can ask for clarification when necessary. It is important to point out that this method of presentation is also possible with the use of a tablet as discussed earlier, however, to repeat, neither teachers nor learners at these paperless schools had any Mathematical software available on their tablets. Mathematics is a subject that requires constant practice for learners to master the skills. However, by learners choosing to use the above-mentioned apps, it evidently affected their Mathematics marks negatively. Two learners voiced their concern regarding a paperless context:

> *I feel like this paperless school would kind of take away teachers, I mean like soon we won't be having teachers and we would be learning on technology … and it's very difficult to answer, ask questions.*
>
> *If you go to paperless most teachers lose their jobs because there won't be a need for them to teach*.

The above two learners believe that teachers would become redundant in a paperless environment because all subject content will be available on their tablets. There may be other learners at these "so-called" paperless schools who envisage classrooms without teachers. The onus is upon the teachers, the school management and the GDE to demystify the concept of a paperless classroom to learners and parents because as Ms Vermaak expressed "… *the technology, we have that for extra for you, but it can't substitute me".*

In June 2013, in a debate entitled "*Will the teaching profession as we know it become obsolete?*" that was co-hosted by the British Council (2013) and the World Innovation Summit for Education (WISE), both teachers and students, who attended this debate, voted against this notion. However, the vote could have gone either way; the vote against the motion only triumphed by a few votes. Professor Martin Hall, the Vice-Chancellor at The University of Salford cautioned that anyone who believed that digital innovations would replace the teaching profession was making a "*series of category errors*" as his students "… *placed great value on face-to-face teaching encounters"* (British Council, 2013). He added:

> *Teaching as we know it is grounded in a very deep appreciation of the true relationship between imparting knowledge and developing learning. Technology allows us to focus on the transformative process of knowledge, that has been the case for centuries…That continuity is critical, new technologies are liberating in allowing great teaching that has always been available become more widely available* (British Council, 2013).

Galligan et al. (2010, p. 41) like Professor Hall emphasised the value that students placed on face-to-face interaction with their lecturers despite the use of technology in the classroom, "*Contrary to the popular belief of many university teachers this did not decrease the on-campus class attendance. In fact, students commented that they came to class for the interaction, and the chance to ask questions".* In addition, Bilal Shakir, the student representative at the debate, agreed with Professor Hall that technology should be used to augment teaching and learning and was adamant that technology could not and would not replace the teacher in the classroom. Furthermore, he stated that the current problems experienced in education stemmed from the systems in place and therefore "*We need to find creative ways to fix the teaching system and invest in teachers, not make teaching obsolete*" (British Council, 2013).

Summary

Greenfield (2015) cited various reasons why iPads should not be used in the classroom and claimed that despite there being a lack of evidence that the use of iPads aid learning, there is still eagerness to include these devices in teaching and learning. She added that although various studies have been conducted on this issue, these studies produced varied results and therefore, she posed the following pertinent question, "*Shouldn't education policy be built on pedagogy, not popularity?*" The OECD (2015, p. 145) report stated "*Despite considerable investments in computers, Internet connections and software for educational use, there is little solid evidence that greater computer use among students leads to better scores in mathematics and reading*". The literature indicates that there is enthusiasm by policymakers to include ICTs, especially tablets in today's classrooms and Gauteng's paperless schools are no exception, however, if research indicates that there is not enough evidence of postive gains of ICT use towards academic performance, *why then does the Gauteng MEC want teaching and learning to be conducted in a paperless environment? Is the context within which teaching and learning is constructed, really important?*

As mentioned previously in the literature review (see Chapter Three) teachers are the most important component of teaching and learning and should be consulted on matters that affect them, however, this does not seem to be the case (Greenfield, 2015). In addition, she pointed out that the use of tablets adds a financial burden on the current education system, which is not limited to the mere provision of these devices but their maintenance as well. In this study, participants indicated that at times when tablets are lost or stolen, it is the responsibility of the parents to replace these devices, which becomes a challenge due to the socio-economic status of these learners and the schools, which was discussed earlier in this chapter. According to Greenfield (2015) "*When the funding for iPads is shifted to parents, such as with BYOD [bring your own device] programmes, the socio-economic inequity inherent in the schooling system only deepens"*. Two of the cases included in this study were paperless schools with differing socio-economic statuses that emanated from the unequal opportunities, due to the apartheid system that was inherent in the South African Education System. Apartheid was abolished in 1994, however, since then despite various attempts to redress the inequalities of the past, these unequal opportunities continue to persist.

The findings from this study and supported by Greenfield (2015), provided various benefits, such as increased communication, access to varied resources both from teachers as well as the internet, learners' excitement and motivation to learn. However, these tablets also become a major distraction to learners and as a consequence they use these devices inappropriately. This inappropriate use is associated with entertainment (playing games, listening to music, watching videos and interaction on social media platforms) as well as the temptation to continuously connect to the internet instead of focusing on the intended purpose, which is for education. These claims are supported by a study conducted at two township paperless schools in Gauteng, South Africa where learners also experienced problems with Wi-Fi connectivity as well as the inappropriate use of technology by learners (Makwela, 2019).

The main research question that this study intended to answer is "***What is the viability of teaching and learning Mathematics using ICTs in a paperless environment***?", is aptly answered by Mr Mdluli from Intaba Secondary School; "It's *practically impossible to abandon the chalk. Not at all! That one is a big no!*" This chapter presented the factors that influenced the viability of teaching and learning Mathematics in a paperless context as presented in the introduction of this chapter. Ms Mbheki believed that a paperless classroom *"Is a dream that is eventually possible but for now, too many factors against it*". She added:

> *I don't think we can get there in 10 years! I don't think we can get there in 10 years! No! No! To go completely paperless like I said if I had 10 learners maybe, but in a Government school with the size … you will find 44, 45 learners in one class lets be, no complete paperless, no not in Maths, not for now, maybe in time, maybe!*

The analysed data confirmed that a paperless classroom is not viable and although some teachers said that it might be possible in the future, the majority could not see the viability nor the sustainability of teaching Mathematics in a paperless environment. Mr Dlamini *said "I must admit I don't foresee it being sustainable… I don't see us in going much with this technology in Mathematics, personally, so I don't think it's sustainable!"* The words of a learner sum up this chapter succinctly: "***We should have technology, we should evolve, we should hit the stars, reach for the stars and everything but not in education, let us not gamble with education!"*** Chapter Eight, which is the final chapter in this thesis discusses the conclusions arrived at from the findings of the study, contributions and limitations and finally the recommendations for future research.

CHAPTER EIGHT

CONCLUSIONS, CONTRIBUTIONS OF THE STUDY, LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

Introduction

This study investigated the viability of teaching and learning Mathematics in a paperless environment using a multiple case-study approach. Chapter One provided an introduction to the study which comprised the rationale, aim and objectives as well as the justification for this study. Chapter Two presented the conceptual framework that underpinned this study followed by the literature review in Chapter Three. A discussion of the methodology used in the study may be found in Chapter Four. In Chapters Five, Six and Seven a discussion of the findings was presented. A discussion of the MEC's statement as well as pertinent themes that emerged from his statement was included in Chapter Five. Chapter Six recounted the numerous challenges faced by teachers and learners, which would inhibit the viability of a paperless classroom. Chapter Seven focused specifically on teachers' and learners' opinions on the viability of teaching and learning Mathematics in a paperless context.

This chapter presents the conclusions arrived at as well as the contributions that this study offers, the limitations and the recommendations for future research. The viability of teaching and learning in a paperless classroom comprises two key components, namely pedagogic and operational viability. Pedagogic viability refers to a teacher's capacity to apply thorough pedagogic theories, while operational viability refers to teachers' technical ability to teach Mathematics in a paperless context. Before conducting this study, it was obvious that viability would be a major theme and consequently formed the central question for the study. Below is a graphic representation of themes that emanated from the final analysis of the data that contributed to the eventual conclusions regarding the non-viability of teaching and learning Mathematics in a paperless classroom. These conclusions are presented below the diagram and are numbered conclusion 1 to conclusion 15.

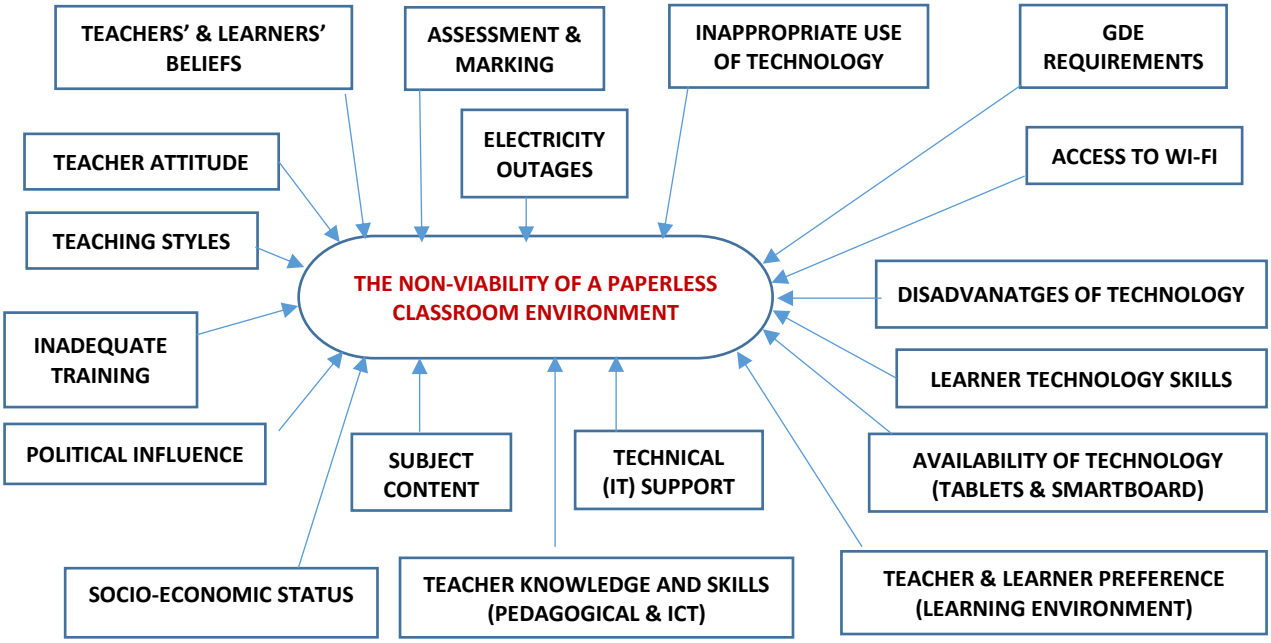

Figure 8.1 Factors that Contribute to the Non-Viability of Teaching and Learning Mathematics in a Paperless Environment

Conclusion 1: Mathematics is NOT being taught in a "paperless" context

As mentioned previously in Chapter One, there appears to be different connotations ascribed to teaching and learning in a paperless environment. Therefore, it was important to establish from the beginning how the Gauteng MEC envisaged teaching and learning to be constructed in a paperless context. His message was clear that in a paperless classroom technology will be used exclusively for teaching and learning. He added that learners of the future would have no concept of what a chalkboard, chalk or duster was as teachers and learners would be working in a paperless context that excluded the use of these as well as pen and paper. However, this does not seem to be the case as is evident from the findings in Chapter Five. Without a doubt, technology such as tablets, access to the internet and smartboards have been provided to schools by the GDE. However, from the three GDE cases that were included in this study, two of them had major challenges with the smartboards not working, learners' tablets either stolen, lost or broken as well as challenges regarding access to Wi-Fi. Various studies as indicated in the literature point towards the benefits of integrating technology in teaching and learning, however, at no point is this integration of technology related to the context of a "paperless" environment. The question, therefore, arises whether teaching and learning Mathematics has to be conducted in a paperless context or should teachers be allowed to make the decision on

how they would prefer to affect the teaching and learning of the Mathematical subject content. The MEC intended to enhance teaching and learning by establishing paperless schools, however, *is a paperless context a necessity to enhance teaching and learning?*

Nurlu (2015) claims that there is a strong relationship between teachers' self-efficacy belief to teach Mathematics and learners' performance, that is, if a teacher's self-efficacy belief is high, then this would result in learners attaining better results. This is because teachers, who have a high self-efficacy belief tend to put in more effort and are more persistent with their learners:

> *They are more open to new ideas and new methods, believe in students' achievements and take responsibility for students' success… are more tolerant, tending to support low-attaining students. They make more effort to help students improve their self-confidence as learners of Mathematics* (Nurlu, 2015, p. 37).

Since self-efficacy belief is instrumental in assisting learners to achieve success, he recommended that this self-efficacy belief towards Mathematics needed to be developed. He added that the learning environment of preservice teachers should be organised in such a manner that augments their abilities to execute the teaching and learning of Mathematics effectively. Furthermore, Nurlu (2015) stated that training should be a continuous process and that teachers' attitudes towards the teaching profession should be reformed.

Although teachers in this study were qualified Mathematics teachers, there are many who are teaching Mathematics despite not having the requisite qualifications (see Chapter One). This lack of qualified Mathematics teachers in South African schools presents several challenges as during their preservice training they did not acquire the necessary pedagogical knowledge and skills to teach the Mathematical content. According to Aksu and Kul (2019, p. 2), Shulman underscored PCK as "… *content knowledge required for teaching*", meaning that teachers needed to know how to prepare the context that would contribute positively to teaching and learning. Therefore, teachers would need to have sound PCK, which is the combination of subject content and pedagogical knowledge, and has a direct influence on the quality of teaching (Aksu & Kul, 2019). They added "T*eachers with strong PCK focus on students' thinking/understanding; they explain things according to students' cognitive level and provide more accurate content by employing educational strategies, such as giving examples and using metaphors"* (Gudmundsdottir, 1987 & Rovegno, 1994 in Aksu & Kul, 2019, p. 2*).* Therefore, it may be assumed that if teachers do not have a sound understanding of the subject content, they will not be able to formulate an appropriate context to effect learning of the subject

content. PCK increases Mathematical efficacy of teachers, and if this increases, then their anxiety decreases, therefore both teachers and policymakers should pay more attention to the advancement of teachers' PCK (Aksu & Kul, 2019). It is important to note that the lack of PCK is exacerbated when teachers have no choice but to teach in a paperless environment as prescribed by the Gauteng MEC. All the teachers in this study indicated their preference for a blended teaching and learning environment; consequently, by the Gauteng MEC prescribing that teaching and learning should be conducted in a paperless context, he is placing undue anxiety on teachers to work in such a context (paperless). This situation is worsened when teachers, who do not have the proper qualifications to teach Mathematics, are "forced" to teach in a paperless context.

In addition to PCK, when technology is integrated into the education process, teachers would have to possess TCK, which is identifying which technology to use and how to use it to teach the content. The effective use of technology would, therefore, be reliant upon the subject content knowledge of the teacher and their ability to teach it. If PCK is lacking, then it may be inferred that the integration of technology would worsen teaching and learning. In a paperless context, both PCK and TCK are crucial.

In this study, it was observed that teachers merely used the technology in the classroom to replicate the traditional method of teaching and learning. That is, the smartboard was used to write on, teachers posed questions to learners, which they answered orally and at no point was there any "interactive" use of the tablet during the lesson by learners, except to access the textbook. Hence, the context of teaching and learning in a "paperless" context as expected by the Gauteng MEC to enhance teaching and learning was not evident and is not what both teachers and learners desire. The findings indicated that both teachers and learners prefer a blended environment for Mathematics and have provided various reasons for their choice (refer to Chapter Five). To make the point again, if the intention is to enhance teaching and learning through the use of technology, *why then should a paperless environment be important?* As the literature indicates all subject content cannot be taught using technology and if this is the case, *would a paperless environment not be negating the intention and purpose of using technology in the classroom, as stated in the Annual Performance Plan 2015/2016 of the GDE?*

Conclusion 2: Teachers prefer to teach Mathematics and learners prefer to learn Mathematics in a blended environment

Despite the Gauteng MEC establishing paperless schools and envisaging that teaching and learning would take place in a paperless context, this is contrary to the current teaching and learning environments at the schools in this multiple case study. Both teachers and learners quite equivocally voiced their preference for a blended learning environment for Mathematics. Their preference for a blended learning environment is attributed to the affordances as well as the constraints that technology imposes when integrated into education. Teachers expressed their challenges when using the smartboard, which related to their lack of technological skills. Learners mentioned that they lacked technological skills despite the assumption by most of the teachers that they are adept regarding technology-use as they were proficient at using smartphones. This assumption by teachers is flawed since the ability to use the smartphone does not necessarily imply that they would be able to use the tablet effectively.

It is important to point out that teachers were not averse to the use of technology but stated that the traditional method of teaching and learning would be used more regularly while technology would be used to enhance the learning process. Perhaps this preference could be traced to their preservice training as Mathematics teachers, as the pedagogy that underpinned their training did not incorporate technology (Nurlu, 2015). Because these are seasoned Mathematics teachers, the change would probably be difficult for them as they are accustomed and comfortable using the traditional methods.

It may be assumed that because the participants are in-service teachers, they have the requisite PCK that they would have gained during their pre-service training. However, when technology is integrated into the classroom TK, TCK, TPK and TPACK are crucial. TK incorporates knowledge regarding the diverse technologies, which range from pen and paper to the use of digital technologies, to name a few: the internet, videos, smartboards as well as the various software packages available to teach Mathematics. When employing TCK teachers should be able to identify which technology could be used to enhance the teaching and learning of the selected Mathematical content. However, when integrating technology in teaching and learning, it is important that teachers support the use of technology with pedagogy for teaching and learning to be effective. Finally, teachers who possess TPACK have the innate knowledge

of the multifaceted relationship between CK, PK and TK. Although teachers may have TPACK, this does not necessarily mean that they would be inclined to teach in a paperless context, considering that they explicitly indicated their preference for a blended environment for the teaching of Mathematics. For a paperless environment to be viable, there is a need for teachers to "buy-into" this notion. Consequently, it may be assumed that if this "buy-in" is overlooked on the part of the GDE and policymakers, a paperless environment would not be viable.

Learners themselves, despite being referred to as "digital natives", (see Chapter Three) preferred to be taught Mathematics using the traditional method while blending the use of technology where appropriate. They were emphatic in their statement that the teaching and learning of Mathematics in a paperless environment was not viable due to the various challenges experienced regarding the integration of ICTs in teaching and learning.

Conclusion 3: GDE requirements contradict a paperless context

It appears as if there is a lack of communication between the Gauteng MEC and the GDE since the GDE requires hardcopies of learners' work as well as paper-based reports from teachers, whereas the Gauteng MEC stated quite categorically that classrooms should be paperless. When a teacher attempted to provide the required documents electronically, he was accused by the district subject facilitator of not fulfilling his duties, although he was following the directive of the Gauteng MEC. Moreover, teachers are given hardcopies of lesson plans by the GDE, which defeats the objective of teaching and learning in a paperless classroom. Koehler (2012, p.1) cautioned that "*Individual teachers, grade-level, school-specific factors, demographics, culture, and other factors ensure that every situation is unique, and no single combination of content, technology, and pedagogy will apply for every teacher, every course, or every view of teaching"*. Therefore, by the GDE providing prepared lesson plans, PowerPoint presentations of Mathematical lessons as well as expecting teaching and learning at designated paperless schools to be conducted in a paperless context, they are assuming that the "one-size-fits-all" notion is applicable to teaching and learning, not taking cognisance of Koehler's (2012) dictum. In addition, despite the MEC's requirements regarding paperless schools, by the GDE insisting on hardcopies, it is obvious that there is no alignment between the requirements of the MEC and the GDE. If this situation persists, *how then can a paperless environment be viable?*

Conclusion 4: The use of tablets to teach and learn Mathematics does not at this stage appear to be viable

Learners who received tablets from the GDE had no choice in the selection of the device to be used in a paperless context. One of the teachers complained that the tablet screen was too small to teach Mathematics (see Chapter Seven), while two ICT members found the storage capacity on learners' tablets to be insufficient. According to the TPACK framework, teachers need to have a thorough understanding of technology to employ it effectively in their classrooms as well as being able to distinguish when the use of technology may support or inhibit the attainment of the aim. Considering that a teacher indicated that the screen size of the tablet is not adequate for teaching Mathematics and this is the technology selected by the GDE, *how then would the teaching and learning of Mathematics in a paperless environment be viable?* To repeat, Koehler's (2012) statement in conclusion 3, has relevance here as well; due consideration should have been given to the type of technology to be used in the classroom since every school, demographics and culture is unique. As mentioned previously, teachers should have been consulted as well as considerable research should have been conducted to ascertain the suitability of tablets for teaching and learning because some learners would prefer to use a laptop instead of a tablet. The above discussion indicates that if the selected technology does not satisfy the needs for teaching and learning, a paperless context would not be viable.

Conclusion 5: Teachers and learners lack technological skills

The Gauteng MEC expected that all teaching and learning in paperless schools would be conducted in a paperless environment. However, for this to be a reality, it would be imperative that teachers and learners have exceptional skills to use technology in such a context; if learners lack the necessary technological skills and assuming teachers are technologically competent, teachers would waste teaching time teaching learners technology skills instead of teaching them the Mathematical content. In this study, teachers and learners were honest in their disclosure regarding their lack of technological skills in the use of the smartboard and tablets. This acknowledgement by both Mathematics teachers and learners demonstrates that they lacked the necessary TK (knowledge of the technology and how to use it), which is fundamental to a paperless environment, consequently, rendering teaching and learning in a paperless context, non-viable.

Conclusion 6: Teachers and learners require continuous training and support

Training emerged as a serious challenge because the majority of the teachers were not *au fait* with integrating technology in teaching and learning. Despite teachers having received training, it was deemed inadequate because it was not targeted at the various levels of each teacher's technological competence and it was not subject-specific. By the training not being subject-specific, teachers found it difficult to incorporate technology in the teaching and learning of Mathematics. When technology was introduced at schools, teachers were given minimal training and the training for learners was limited to how to access resources on the tablet. Teachers assumed that learners have the necessary technological skills, however, many of the learners stated that they would have appreciated training because their skills were lacking. To reiterate the majority of the teachers in this study were seasoned teachers who indicated that neither in their pre-service training nor the technological training that they attended, focused on how to integrate technology and pedagogy (TPK) pertaining to the Mathematical content. Koehler and Mishra (2009 in Koehler, 2012, p. 1) state:

> *TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones.*

With reference to the above excerpt and the findings of this study, it is evident that the development of teachers' TPACK was not considered when training was designed to implement technology in the classroom, as teachers claimed that the training they received was not subject-specific. If TPACK does not underpin the training offered by the GDE, teachers would lack the confidence and ability to integrate technology in their pedagogy. In a paperless context, this lack of teachers' TPACK, would contribute to the non-viability of teaching and learning Mathematics in a paperless context.

In addition to training, technological support for teachers and learners is key for technology to be used to its optimum. In this study, however, technological support was identified as a major challenge. In a paperless environment, technological support should provide immediate solutions to problems which disrupt teaching and learning; however, this would only be possible in an ideal situation, which is virtually non-existent. In addition, although teachers

may have the requisite TPACK, if the technology is non-functional and the technological support is not available immediately, then teaching and learning Mathematics in a paperless context will not be viable. However, if it were a blended environment, these problems would not impede teaching and learning, which could continue using the traditional method of teaching when technology-use proved to be problematic.

Conclusion 7: The current infrastructure presents problems for a paperless environment

At the four sites where this study was conducted, infrastructure was cited as an additional constraint to teaching and learning using technology. Electricity outages caused serious problems with teaching and learning because in the absence of electricity, this came to a halt. All schools apart from one, had a generator that could be used during power outages; however, the generator was not sufficient to provide power to the entire school. All teachers agreed that without electricity, they could not teach in a paperless context.

In addition, all participants indicated that access to Wi-Fi was a major problem that inhibited access to the internet as well as the Intranet. The participants from a site indicated that they did not have Wi-Fi access for two years, however, this was not due to electricity outages but to the continual theft of computer equipment. At another school, despite having access to Wi-Fi, the participants indicated that since the strength of the Wi-Fi signal differed across the school, it affected their ability to download information when requested by the teacher. Whether teachers have the necessary TPACK or not, it is of no consequence if the infrastructure does not support teaching and learning in a paperless context, consequently, rendering the paperless context non-viable.

Conclusion 8: Theft and damaged technological devices impedes teaching and learning

When tablets are broken, lost or stolen, it becomes impossible to affect teaching and learning in a paperless context. This challenge emerged as a major theme that inhibited teaching and learning when using technology. Consequently, the above-mentioned problem would pose a barrier to teaching and learning despite teachers having the requisite TPACK. For a paperless

classroom to be viable, it is imperative that all technological devices are available and are working optimally as teaching and learning in a paperless environment is dependent upon an "ideal" situation where broken, lost or stolen tablets should not be an impediment.

Conclusion 9: Learners use the tablet to access the textbook and the Internet only

The findings from this study indicated that learners merely used the tablet to access the textbook and the internet when Wi-Fi access was available. At all four sites, the participants alluded to the tablets having no Mathematical software on them. Consequently, teachers found that the use of tablets placed additional responsibility on them, as learners used the technology inappropriately, which inadvertently affected their results negatively. Considering that teachers have to contend with large numbers of learners in classrooms, it is practically impossible for the teacher to ensure that all learners are using the technology for the intended purpose. It may be assumed that if Mathematical software was available on the tablets, learners would perhaps use this software to learn and practice their Mathematics, however, this will most probably not eliminate the inappropriate use of the tablets. The fact that there is no Mathematical software available on learners' tablets, how then can Mathematics be taught in a paperless context? Therefore, teaching and learning as it currently exists in the selected sites, which is a blended environment, provides evidence that teaching and learning in a paperless context is non-viable and not sustainable.

Conclusion 10: All Mathematical content cannot be taught solely using technology

Most of the teachers in this study, who had a considerable number of years teaching Mathematics, were all convinced that it is impossible to teach all the content in Mathematics solely using technology. This opinion of Mathematics teachers is supported by the literature in Chapter Three, where researchers claimed that since all subjects are not the same, technology-use may be suitable to teach the content of some subjects, while the content of other subjects may not lend themselves to technology-integration.

If Mathematics teachers are well versed with the Mathematical content, they would be able to recognise when the use of technology for this subject would be appropriate or not. This is where teachers should have the requisite TCK and consequently, the onus is on the teachers to choose when or when not to employ technology to teach that content. In addition, the fact that teachers were able to identify the constraints and affordances that the use of technology would impose when teaching Mathematics, indicated that they possessed some kind of TPK. The choice of whether to use technology or not would be based upon their TPACK, which is the requisite knowledge for teachers to integrate technology that would be appropriate to teach specific Mathematical content.

In addition, the components of knowledge, CK, PK and TK are necessary when teachers use insight to integrate technology in teaching and learning because they understand the complexity between the above-mentioned components of knowledge. Despite not having interviewed teachers regarding their knowledge of TPACK, it was evident that they displayed some TCK since they mentioned that all Mathematical content could not be taught using technology only. This implied that they were able to identify when technology would enhance or constrain the teaching and learning of certain Mathematical concepts. Once again, if all Mathematical content cannot be taught using only technology, this renders teaching and learning non-viable in a paperless context.

Conclusion 11: The use of technology is unsuitable to assess Mathematical content

In education, assessment is integral to determine whether learners have acquired the necessary knowledge and skills of a subject. Therefore, when assessments are formulated, teachers must take cognisance of Bloom's taxonomy (Chapter Three) and include questions from more than one level. Although the current assessments available for Mathematics using technology were only multiple-choice, true or false and matching questions as alluded to by the Mathematical teachers in this study, these questions assessed learners' recall, understanding and application of knowledge and skills according to Bloom's taxonomy. However, learners had to work out the solution to arrive at the answers on paper before inserting/choosing the correct answer to the question using technology.

The fact that learners used paper to arrive at the solution meant that these questions were not simply questions based on recall (level 1) but required learners to apply their understanding (level 2) and application of the facts, rules and concepts (level 3). However, learners were not required to submit the working that they had completed on paper and therefore, teachers could not assign part marks to the answers, which is a requirement for Mathematics. In addition, to assigning part marks, teachers would also be able to identify where the learner went wrong in their solution to the problem, which would assist them in correcting learners' errors. This is indicative that teachers in this study display TPACK, since TPACK is at the heart of combining technology with pedagogy for effectual teaching using technology (Koehler & Mishra, 2009). The fact that Mathematics cannot be assessed appropriately and holistically using technology exclusively, this would imply that due to the current situation as it pertains to these so-called "paperless" schools, assessing Mathematics in a paperless environment would not be viable.

Conclusion 12: Marking of assessments using a tablet is difficult

Despite not having posed a question about the marking of Mathematical assessments using tablets, one teacher who has marked Grade 12 final examination papers in Mathematics for several years, maintained that marking assessments electronically would be difficult. Based on her experience and style of marking, she indicated that due to the large numbers of scripts to be marked, marking on a tablet would be onerous. She indicated that she often refers back to certain scripts when she could not understand the solution that was provided by the learner. She preferred to give the learner the benefit of the doubt by attempting to understand how they arrived at the solution instead of assigning a zero because their solution differed from the marking memorandum. In her opinion, she believed that this process would easily be affected when assessments are paper-based and marked as thus.

The purpose of using technology in the classroom is to enhance teaching and learning. However, if this teacher claims that the use of technology to mark assessments is arduous, *why then should assessments be conducted using technology?* If the process of marking using technology does not benefit the marker (teacher), especially regarding the ease of marking, it may be assumed that they would be against the use of technology for this purpose. As a result, affecting teaching and learning of Mathematics in a paperless context, which includes assessments and their marking, would render a paperless environment non-viable.

Conclusion 13: The socio-economic status of the school and learners, as well as social factors, are detrimental to teaching and learning in a paperless context

As a legacy of apartheid, many South Africans still have to contend with the remnants of apartheid. This legacy permeates many lives specifically in the historical townships and informal settlements as many people are unfavourably affected as a result of unequal opportunities. Because of these unequal opportunities many schools in townships experience financial difficulties as a result of being non-fee-paying schools. Despite receiving funding from the Government, this is inadequate as indicated by participants in this study. An example of inadequate funding at a school is where many tablets were stolen, due to numerous break-ins, because they were unable to provide the necessary security. This is detrimental to teaching and learning in a paperless context.

Another challenge that permeates many learners' lives is that of their socio-economic status. Some learners have a single parent, while others could perhaps be from child-headed homes. Lack of finances could affect these as well as learners who have both parents. Many homes do not have electricity, which could affect the use of technology negatively since learners may not be able to charge their tablets. Although charging banks are available at schools, learners may forget to charge their tablets before leaving school and with regard to child-headed homes, these learners would have to hurry back home to attend to their chores. In addition to the socio-economic status, parental involvement and interest in their children's education are imperative.

Many participants stated that parents were more focused on providing the necessities for their children due to the lack of finance. An additional reason could be the educational background of some parents, which prevented them from assisting with their children's schoolwork due to their level of education. Bearing in mind the above discussion, the sole use of technology would pose a challenge in a paperless context since no learning would take place if the technology is unavailable. It is important to point out that this situation could be avoided if teaching and learning took place in a blended environment. Consequently, it may be inferred that due to the socio-economic status and social factors, a paperless context would not be viable.

Conclusion 14: The disadvantages of technology-use impedes learning in a paperless environment

A significant finding was that both teachers and learners firmly believed that the use of the tablet was a distraction to learners. In addition, teachers indicated that learners forgot to refer to the information that they had captured when using the camera on their tablets for study purposes. Because learners have access to "Google", they omit to ask for clarification in class. What was concluded is that some learners are over-reliant on their tablets and assume that the use of these can replace the teacher in a paperless context. Additionally, specific software that learners had used to complete their Mathematical tasks, such as yHomework and PhotoMaths, influenced their Mathematics results negatively. Considering the above-mentioned disadvantages related to technology-use in the classroom, *how then can the teaching and learning of Mathematics in a paperless environment be viable?* To reiterate, if teaching and learning was conducted in a blended environment, where the use of technology posed a disadvantage, teachers and learners could choose to use pen and paper.

Conclusion 15: Teachers' attitudes to a paperless environment

Eickelmann and Vennemann (2017) claim that the successful integration of ICTs in teaching and learning is greatly influenced by teachers' beliefs as well as their attitudes. The findings from this study concur with the above researchers as well as the literature review as found in Chapter Three. If teachers have a positive attitude towards ICT integration it may be construed that they have the necessary TPACK, likewise, if they do not believe that the integration of ICTs would enhance teaching and learning, this may be attributed to their lack of TPACK. In addition, it is important to understand that it is human nature to be resistant to change and especially when change is imposed, it is most likely that teachers will be unenthusiastic.

Teachers' attitudes in this study, indicated that they were opposed to the idea of teaching and learning Mathematics in a paperless environment, however, they were in favour of a blended environment since they believed this would be more suitable to the teaching and learning of Mathematics. What is important to note, is that teachers are not unwilling to integrate technology in teaching and learning but are opposed to the sole use of technology in a paperless

context. If teachers do not believe that they can teach in a purely paperless environment, then teaching and learning in paperless classrooms becomes non-viable.

Contributions of this Study

This study contributes to the understanding of how ICTs are used in the Mathematics classroom, taking the experiences of both teachers and learners regarding the use of ICTs, the challenges that they experienced in this regard as well as the viability of integrating ICTs in a paperless context. The findings from this study could contribute to the policy of technology integration in the classroom. In addition, the results of this study will be made available to the GDE, which could be used to re-evaluate their expectations of how teaching and learning should be constructed in a paperless context. I concur with Meyer and Gent's (2016) findings that the focus should be on developing the capacity of teachers to use technology effectively to enhance teaching and learning. This study revealed that both teachers and learners lack technological skills and therefore, require training that must be on-going and constructed according to the skill level of the teachers. Perhaps the GDE will use this important finding to re-examine how training pertaining to technology integration is being conducted and take teachers' advice on the type of training that they require.

Paperless schools will benefit from the information elicited by this study through the dissemination of results. Additionally, the findings from this study will illuminate the viability of teaching and learning Mathematics in a paperless classroom and consequently, contribute to the literature on the subject. No matter what the anticipated benefits may be, there are always limitations in a study of this nature.

Limitations of the study

As anticipated, there are limitations in every study despite how meticulous the researcher may have been. The major limitation of this study was that despite these schools being identified and established as paperless schools, no teaching and learning was conducted in a paperless context. The purpose of conducting observations of Mathematics lessons was to understand how teaching and learning took place in a paperless context as well as to ascertain the technological skills of both learners and teachers. However, since teaching and learning was

not conducted in a paperless environment, it was not possible to observe the technological skills of both teachers and learners. Additionally, it was not possible to collect data on how teaching and learning of Mathematics would have been conducted in a paperless environment, however, it was obvious that the teaching and learning of Mathematics in a paperless context is not viable.

Due to the limited number of schools identified as paperless in Gauteng, South Africa, convenience sampling was employed to select the cases. Data was collected from participants from one affluent private school, two township schools and from one urban ex-Model C school, that was the pre-cursor to the establishment of paperless schools. Although, the cases included a fair representation of the population under study, the findings may only be generalised to the cases included in this study.

In-depth semi-structured face-to-face interviews were held with Mathematics teachers to collect the data for this study. According to Neuman (2000), interviewing may be limiting as the responses obtained from participants may be misrepresented due to prejudice, rage, anxiety or other personal or emotional factors. A few teachers claimed that they had exceptional technology skills, however, none of these skills could be verified during the observations of Mathematics lessons as teachers simply used the smartboard as a replacement for the chalkboard/whiteboard. In addition, some Mathematics learners claimed that they had excellent technology skills. Once again, these skills could not be confirmed as learners only used the tablets in the class to access the textbook. Other than accessing the textbook, there was no other Mathematical activity that was completed using the tablet.

Many learners who formed part of the focus group discussions were English second-language speakers, who at times found it difficult to express themselves in English. Consequently, their answers to questions were not detailed and required considerable prompting from the interviewer to urge learners to participate in the discussion and to elaborate on their answers.

A focus group may comprise participants with diverse strengths such as some participants being more vocal and confident when compared to others. During the focus group discussions held with learners at the four sites, some learners dominated the conversation. Consequently,

those participants, who lacked the confidence to voice their opinions, refrained from contributing to the discussion.

Finally, the results from this study may not be generalisable when considering the significance of context since each site is unique regarding situations, history as well as culture (Patton, 2002; Neuman, 2000). However, the findings from this study underscore the challenges experienced by teachers and learners regarding the incorporation of ICTs in teaching and learning, consequently, providing valuable insight into the viability of teaching and learning Mathematics in a paperless environment.

Recommendations for future research

Considering that this study only included four paperless schools that experienced major challenges regarding the incorporation of ICTs in the teaching and learning of Mathematics, it would be important to extend this research to include other "so-called" paperless schools to ascertain whether they experience similar conditions. Based on the findings from this study, future research could be conducted over a wider spectrum to include districts from other provinces in South Africa. Perhaps in a new study, document analysis, as well as video recordings, could be used to collect data on how teaching and learning using ICTs takes place in a paperless context.

An additional recommendation would be to spend a longer period, possibly six months or a year observing how teachers incorporate ICTs in the teaching and learning of Mathematics. For this study, I assumed that teachers had the requisite Mathematical content knowledge because I felt that as this was a sensitive area to investigate, teachers may have been offended and chosen not to participate. If a longer period is spent collecting the data, the researcher would be able to gauge through the observations whether teachers have the requisite content knowledge to teach Mathematics or not.

Summary

Since books, pens and paper have been used throughout the ages as well as teachers being trained to teach using the traditional method of teaching and learning, the transition to a

paperless environment would not be an easy process, as the findings of this study suggest. During the search for literature on schools that have gone "completely" paperless, none could be found. In fact, although these schools are identified as paperless schools, ICTs are used to augment teaching and learning. The MEC envisaged all Gauteng schools becoming paperless by the year 2018. To reiterate we are now in 2020 and Gauteng schools are nowhere close to being paperless.

In addition, this study set out to answer the following main research question:
What is the viability of teaching and learning Mathematics using ICTs in a paperless classroom?

The following sub-questions assisted in answering the main research question.

- What are the requisite ICT skills for both teachers and learners to integrate ICTs in the teaching and learning of Mathematics?
- What are teachers' and learners' attitudes and opinions regarding the use of ICTs to teaching and learning Mathematics in a paperless classroom?
- How do teachers and learners experience the teaching and learning of Mathematics in a paperless classroom?

The conclusions discussed above clearly answered the research questions and demonstrated that a paperless environment would not be viable for the teaching and learning of Mathematics and cannot be achieved in a short space of time.

The Gauteng MEC and the GDE should liaise with one another as there is a disparity in their requirements, which places considerable stress on teachers as there is no consensus regarding requirements. In addition, technical support presented a barrier to the incorporation of technology in teaching and learning as both teachers and learners claimed that this was lacking. The onus is upon the GDE to ensure that on-site technical support caters to the needs of teachers and learners. They should realise that the delays caused by having to report problems to the GDE and awaiting their responses, deters teachers from implementing technology in teaching and learning.

Despite this address being made twenty years ago, it still holds relevance today. In his keynote address at the National Educational Computing Conference (NECC) in Atlanta, Georgia, the president of Intel stated; "*Computers aren't magic but teachers are, students are*" (Barrett, 2000). What may be inferred from this statement is that both teachers and learners need to have the requisite technological skills to use technology to its optimum. Another source that is relevant despite its age is Lambert (2009, p. 6), as he indicated that it is necessary to take into account the human factor that is essential in teaching and learning since *"... these technologies themselves will someday become obsolete, the student-teacher relationship will not*".

In conclusion to quote Ms Mbheki, "*I think that, that is a dream, to get to a point where really learners stop using paper in class. But I think it's a dream that is still far for now"*. Perhaps a far-fetched dream, which begs the question:

"*To teach or not to teach in a paperless context, that is the question?*"

(Apologies to Shakespeare)

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APPENDICES

APPENDIX A: CONSENT FORMS

A1: School Consent form

Dear Sir/Madam

PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOL

My name is Rehana Minty. I am a registered PhD student in the School of Education at the University of the Witwatersrand.

I am conducting research on the Viability of Teaching and Learning Mathematics using Information and Communication Technologies (ICTs) in a Paperless Classroom.

My research involves collecting data using in-depth face-to-face interviews with Mathematics teachers who teach in paperless classrooms. Focus group discussions will be held with learners from these paperless classrooms. Additionally, classroom observations will be conducted to obtain first hand information on how teaching and learning takes place in a paperless classroom. Furthermore, observations may provide alternative means for the researcher to document the experiences of participants who are unable to express their true emotions and experiences through interviews and thus may contribute towards the validity of the study.

This study will not interfere with the timetable in any way as interviews with Mathematics teachers will be conducted during times convenient for the teacher and at venues where teachers would be comfortable. The time and venue of the focus group discussion will be chosen by the learners of that specific group. Learners will also be given the opportunity to consult with me if by any chance they have a free period possibly because of the absence of a teacher. In this case the class teacher may also assist in arranging for the focus group discussion to take place. Concessions will be made to accommodate learners whenever they are available.

The reason why I have chosen your school is because your school has been identified as one of the paperless schools. I am conducting case study research that requires a number of schools to be included in my study, which is the Viability of Teaching and Learning Mathematics using Information and Communication Technologies (ICTs) in a Paperless Environment.

I am inviting your school to participate in this research because initially it was identified as a paperless school. Additionally, teachers from paperless schools will benefit from the information elicited by this study through the dissemination of results. Through sharing the findings of this study, teachers will be informed about the experiences, opinions, attitudes and expectations of other teachers and learners who teach and learn Mathematics in a paperless environment. The experiences of both teachers and learners regarding the use of ICTs, the challenges that they face in this regard as well as the viability of integrating ICTs in the teaching and learning of Mathematics in a paperless classroom will be clarified.

The participants will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

The names of the research participants and identity of the school will be kept confidential at all times as pseudonyms will be assigned to maintain anonymity in all academic writing about the study. Your individual privacy will be maintained in all published and written data resulting from the study.

All research data will be destroyed within 3-5 years after completion of the project.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Rehana Minty (Mrs)
rehanam@uj.ac.za

A2: INFORMATION SHEET LEARNERS

Dear Learner

INVITATION TO PARTICIPATE IN RESEARCH ON PAPERLESS SCHOOLS

My name is Mrs Rehana Minty, and I am a registered PhD student in the School of Education at the University of the Witwatersrand. I am conducting research on the Viability of Teaching and learning Mathematics using Information and Communication Technologies (ICTs) in a Paperless Classroom.

My research involves collecting data on how Mathematics is taught and learnt in a paperless classroom. You are invited to participate in a focus group discussion which consists of seven to ten learners and the duration is under an hour. A focus group is used to obtain opinions, expectations, experiences and attitudes of a specific subject of interest, in this case learning Mathematics in a paperless classroom. You will be expected to provide information and add to what others in the group have said. The focus group discussion will not disrupt your normal classroom and school activities as you will be required to indicate your availability. Classroom observations will also be conducted to obtain information on how teaching and learning takes place in a paperless classroom. Your learning experience will not be interrupted by my presence in the classroom.

Would you like to participate in the focus group discussions for this study? I need your help with providing information on your expectations, experiences, attitudes and opinions of learning Mathematics in a paperless classroom. The information that you provide will be valuable as it will indicate whether teaching and learning Mathematics in a paperless classroom can be sustained.

Remember, this is not a test, it is not for marks and it is voluntary, which means that you do not have to do it. Also, if you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

Please note that the focus group discussions will be audio recorded but your identity will be protected as you will choose a name to be assigned for yourself. All information about you will be kept confidential in all my writing about the study. Also, all collected information will be stored safely and destroyed within 3-5 years after I have completed my project.

Your parents have also been given an information sheet and consent form, but at the end of the day it is your decision to join us in the study.

I look forward to working with you.

Please feel free to contact me if you have any questions.

Thank you
Mrs Rehana Minty
rehanam@uj.ac.za

A3: LEARNER CONSENT/ASSENT FORM

Please fill in the reply slip below if you agree to participate in my study called:

The Viability of Teaching and Learning Mathematics Using Information and Communication Technologies (ICTs) in a Paperless Classroom.

My name is: _____ Grade: _____

	Circle one
Permission to observe you in class	
I agree to be observed in class.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped during the interview or observation lesson	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be part of a focus group discussion	
I would like to be interviewed for this study.	YES/NO
I know that I can withdraw from the discussion at any time	YES/NO

Informed Consent/Assent

I understand that:

- my name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can request not to be audiotaped.
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Signature_____ Date_____

A4: INFORMATION SHEET PARENTS

Dear Parent

My name is Mrs. Rehana Minty, and I am a registered PhD student in the School of Education at the University of the Witwatersrand.

I am conducting research on the Viability of Teaching and Learning Mathematics using Information and Communication Technologies (ICTs) in a paperless classroom.

My research involves collecting data on how Mathematics is taught and learnt in a paperless classroom. Your child has been invited to participate in a focus group discussion which consists of seven to ten learners and the duration is under an hour. A focus group is used to obtain opinions, expectations, experiences and attitudes of a specific subject of interest, in this case learning Mathematics in a paperless classroom. Your child will be expected to provide information and add to what others in the group have said. The focus group discussion will not disrupt the normal classroom and school activities as your child will be required to indicate his/her availability. Classroom observations will also be conducted to obtain information on how teaching and learning takes place in a paperless classroom. Your child's learning experience will not be interrupted by my presence in the classroom. The reason why I have chosen your child's class is that the school has been identified as one of the paperless schools. Would you mind if your child participates in the focus group discussion and is observed in the classroom, although no individual child will be observed but the class as a whole.

Your child will not be advantaged or disadvantaged in any way and will be reassured that permission to participate may be withdrawn at any time during this project without any penalty. There are no foreseeable risks in participating and your child will not be paid for participating in this study.

Your child's name and identity will be kept confidential at all times as fictitious names will be used in all academic writing about this study. His/her individual privacy will be maintained in all published and written data resulting from the study.

All research data will be destroyed within 3-5 years after completion of the project.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,
Mrs Rehana Minty
rehanam@uj.ac.za

A5: PARENT'S CONSENT FORM

Please fill in and return the reply slip below indicating your willingness to allow your child to participate in the research project entitled:

The Viability of Teaching and Learning Mathematics Using Information and Communication Technologies (ICTs) in a Paperless Classroom

I, _____ the parent of _____

Circle one

Permission to observe my child in class

I agree that my child may be observed in class. YES/NO

Permission to be audiotaped

I agree that my child may be audiotaped during interview or observations. YES/NO

I know that the audiotapes will be used for this project only YES/NO

Permission to participate in a focus group discussion

I agree that my child may participate in the focus group discussion. YES/NO

I know that s/he can withdraw from the discussion at any time YES/NO

Informed Consent

I understand that:

- my child's name and information will be kept confidential and safe and that my child's name and the name of the school will not be revealed.
- s/he does not have to answer every question and can withdraw from the study at any time.
- s/he can ask not to be audiotaped
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Signature_____ Date_____

A6: INFORMATION SHEET TEACHERS

Dear Sir/Madam

My name is Mrs Rehana Minty, and I am a registered PhD student in the School of Education at the University of the Witwatersrand.

I am conducting research on the Viability of Teaching and Learning Mathematics using Information and Communication Technologies (ICTs) in a Paperless Classroom.

My research involves collecting data using in-depth face-to-face interviews with Mathematics teachers who teach in paperless classrooms. Focus group discussions will be held with learners from these paperless classrooms. Additionally, classroom observations will be conducted to obtain first hand information on how teaching and learning takes place in a paperless classroom. Furthermore, observations may provide alternative means for the researcher to document the experiences of participants who are unable to express their true emotions and experiences through interviews and thus may contribute towards the validity of the study.

This study will not interfere with the timetable in any way as the interview with you will be conducted during a time and venue that is convenient for you. The time and venue of the focus group discussion will be chosen by the learners of that specific group. Learners will also be given the opportunity to consult with me if by any chance they have a free period possibly because of the absence of a subject teacher. In this case the class teacher may also assist in arranging for the focus group discussion to take place. Concessions will be made to accommodate learners whenever they are available.

The reason why I have chosen your school is because your school has been identified as one of the paperless schools. I am conducting case study research that requires a number of schools to be included in my study, which is the Viability of Teaching and Learning Mathematics using Information and Communication Technologies (ICTs) in a Paperless Environment.

You have been identified as a teacher who teaches Mathematics in a paperless classroom and you are consequently, invited to participate in this study. You are expected to share your opinions, expectations, experiences and attitudes to the teaching and learning of Mathematics in a paperless classroom. It is anticipated that teachers from paperless schools will benefit from the information elicited by this study through the dissemination of results. Through sharing the findings of this study, teachers will be informed about the experiences, opinions, attitudes and expectations of other teachers and learners who teach and learn Mathematics in a paperless environment. The experiences of both teachers and learners regarding the use of ICTs, the challenges that they face in this regard as well as the viability of integrating ICTs in the teaching and learning of Mathematics in a paperless classroom will be clarified.

Your name and identity will be kept confidential at all times as pseudonyms will be assigned to each teacher who consents to participate in this study. Anonymity and individual privacy will be maintained in all academic writing about this study as well as in all published and written data resulting from the study.

All research data will be destroyed within 3-5 years after completion of the project.

Your participation is voluntary, so you can withdraw your permission at any time during this project without any penalty. There are no foreseeable risks nor remuneration for participating in this study.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,

Mrs Rehana Minty
105 Kei Rd, Farrarmere, Benoni, 1501
rehanam@uj.ac.za
081 532 4708

A7: TEACHER'S CONSENT FORM

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called:

The Viability of Teaching and Learning Mathematics Using Information and Communication Technologies (ICTs) in a Paperless Classroom

I, _____ give my consent for the following:

	Circle one
Permission to observe your class	
I agree to be observed in class.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped during the interview or observation lesson	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be interviewed	
I would like to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO

Informed Consent

I understand that:

- my name and information will be kept confidential and safe and that my name and the name of my school will not be revealed as pseudonyms will be assigned.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped and observed.
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Signature_____ Date_____

APPENDIX B: ETHICAL CLEARANCE

B1: UNIVERSITY OF THE WITWATERSRAND ETHICS CLEARANCE

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

24 October 2017

Student Number: 1596928

Protocol Number: 2017ECE033D

Dear Rehana Minty

Application for Ethics Clearance: Doctor of Philosophy

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

The Viability of Teaching and Learning Mathematics Using ICTs in a paperless classroom

The committee recently met and I am pleased to inform you that **clearance was granted**. However, there were a few small issues which the committee would appreciate you attending to before embarking on your research.

The following comments were made:

- Project information, avoid the use of abbreviations in your title.
- Please indicate in which geographic area and the number of schools involved in your research

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

M Mabeta

Wits School of Education

011 717-3416

Cc Supervisor: Dr Ian Moll

B2: GAUTENG DEPARTMENT OF EDUCATION CLEARANCE

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**03 November 2017**
Validity of Research Approval:	**05 February 2018 – 28 September 2018** **2017/313**
Name of Researcher:	**Minty R**
Address of Researcher:	**105 Kei Road**
	Farrarmere
	Benoni 1501
Telephone Number:	**(011) 559 6345 081 532 4708**
Email address:	**rehanam@uj.ac.za**
Research Topic:	**The Viability of Teaching and Learning Mathematics Using Information and Communication Technologies in a Paperless Classroom**
Number and type of schools:	**Five Secondary Schools**
District/s/HO	**Ekurhuleni North, Johannesburg East, Ekurhuleni South and Gauteng East**

Re: Approval in Respect of Request to Conduct Research

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

03/11/2017

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted: 1

Making education a societal priority

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

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

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

Kind regards

.....

Ms Faith Tshabalala
CES: Education Research and Knowledge Management

DATE: 03/11/2017

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

APPENDIX C: INTERVIEW SCHEDULE (TEACHERS)

1. Explain what you understand by the term “paperless classroom”.

2. The MEC made the following statement at a press conference:

   "*Tomorrow morning in this school, we are officially burying the chalk board, we are officially burying the duster, we are officially burying the chalk. Gone are the days when they have to write in exercise books and hand in the assignment*"

   How do you feel about the statement that the MEC made regarding paperless schools?

3. What in your opinion is the viability of teaching and learning Mathematics in a paperless classroom?

3.1 **Probe**: Describe what your expectations are regarding the teaching and learning of Mathematics in a paperless environment.

4. Discuss the necessary technological and pedagogical skills that are required for you to integrate technology to teach Mathematics in a paperless classroom.

5. How would you as a Mathematics teacher describe your technological and pedagogical knowledge and skills to integrate ICTs in the teaching and learning in a paperless classroom?

6. Describe the changes, if any that you had to make in your teaching style when teaching Mathematics in a paperless environment. (What did you actually change?)

7. In your opinion, what are the necessary skills that learners should have to enable you to teach Mathematics in a paperless classroom?

8. Describe your experience and reflections on when you began integrating ICTs in the teaching and learning of Mathematics in a paperless classroom.

9. Explain how you assess learners in a paperless environment.

10. Explain whether you are required to use any specific software to teach Mathematics in a paperless classroom.

    10.1 Describe the effectiveness of the selected software to teach Mathematics.

11. Describe the training you received if any, on the selected software and technology that you are required to use in teaching Mathematics in a paperless classroom.

12. Tell me about the support that you received from your school management.

13. What are some of the challenges you have experienced in teaching Mathematics in a paperless classroom? (connectivity/bandwidth, learners without technology, power failures, access to lesson plans)

    13.1 Explain whether there are any advantages and disadvantages of teaching and learning Mathematics in a paperless environment.

14. What are your concerns regarding teaching and learning in a paperless classroom?

APPENDIX D: FOCUS GROUP DISCUSSION SCHEDULE (LEARNERS)

Introduction the session

Thank you for agreeing to participate in this focus group discussion. The purpose of this discussion is to find out how you feel about Mathematics being taught and learnt in a paperless environment. In a paperless environment, the entire Mathematics lesson is taught without the use of pen and paper and the use of the chalkboard. This means that all teaching and learning takes place with the use of technology. During this time together, I will ask questions and we will engage in discussion in order to answer those questions. There are no right or wrong answers or opinions and attitudes, just feel free to say what you really think and how you feel about the topic. (Assure learners of anonymity and confidentiality…). Assign numbers to learners.

Discussion 1: Experiences on teaching and learning Mathematics in a paperless classroom

Q.1 Describe your experience of teaching and learning Mathematics in a paperless classroom.

Q.2 Describe your technology skills.

Discussion 2: Expectations on teaching and learning in a paperless classroom

Q.3. Explain what you expected when you first heard about your school being a paperless school.

Q.4. Describe whether your expectations were met.

Discussion 3: Attitudes towards teaching and learning Mathematics in a paperless classroom

Q.5. What are your feelings about learning Mathematics in a paperless classroom?

Discussion 4: Likes and Dislikes

Q.6. What do you like most about learning Mathematics in a paperless classroom?

Q.7. What do you like least about learning Mathematics in a paperless classroom?

Q.8. Do have anything else to add to what we discussed.

APPENDIX E: CLASSROOM OBSERVATION SCHEDULE

School Pseudonym: _____

Grade: _____ **Teacher Pseudonym: _____**

Number of Learners: _____ Date: _____

Description of the classroom

- Describe the physical space

  Is the classroom a paperless environment

  _____

  size of classroom

  _____

  Whiteboard

  _____

  Layout of desks

  _____

  Teachers Table

  _____

  Poster display

  _____

  Any other features

  _____

  Suitability of the classroom

  _____

- Is the classroom conducive to teaching and learning?

  _____

  _____

- What tells the observer that this is a Mathematics classroom?

  _____

The use of technology in the classroom

- What technologies are found in the classroom?

  _____

  _____

- What technologies are being used to teach Mathematics?

  _____

  _____

- What technologies do learners use to learn Mathematics?

  _____

  _____

- Is the software used effectively by the teacher to teach concept?

  _____

  _____

  _____

Discipline regarding learner conduct in the classroom

- How does the teacher establish/enforce the tone of the classroom?

  _____

  _____

  _____

- What factors contribute to making the classroom an effective learning environment?

  _____

  _____

  _____

- Describe any significant events that may occur. How did it begin, develop and end? What were the teachers and learners' reactions? How does the teacher "deal" with disruptive learners?

  _____

_____

_____

_____

- Learner discipline with the use of technology

_____

_____

_____

Teaching learners without tablets

- How do teachers manage to teach when learners do not have a tablet to work with?

_____

_____

_____

Development and flow of the lesson/Teaching Style

- How does the lesson begin?

_____

_____

_____

- What lesson activities are included?

_____

_____

_____

- Are assignments/homework given at the end of the lesson?

_____

_____

_____

- Identify and describe teaching styles employed by the teachers

_____

_____

_____

- Types of questions asked from the three broad categories namely knowledge-based, application of knowledge and analysis will assist in identifying the pedagogical knowledge.

_____

_____

_____

Interpersonal Interactions

- What type of classroom communication takes place and how appropriate is it?

_____

_____

_____

- What is the teacher's role and what evidence indicates whether learners are actively involved in learning?

_____

_____

_____

Teacher and learners' Technological skills

- Describe the technological skills displayed by the teacher

_____

_____

_____

- Describe the technological skills of learners

_____

_____

_____

Other aspects observed

- Variety and types of learning materials used

_____

_____

- Use of textbooks

  _____

  _____

- Pen and paper

  _____

  _____