The integration of ICT by Mathematics teachers in the classroom

by

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Declaration

I declare that the dissertation/thesis, which I hereby submit for the degree magister educationis at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Ruan Kapp

30 November 2017

Ethical Clearance Certificate

Faculty of Education

RESEARCH ETHICS COMMITTEE

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This Ethics Clearance Certificate should be read in conjunction with the Integrated Declaration Form (D08) which specifies details regarding:

- Compliance with approved research protocol,
- No significant changes,
- Informed consent/assent,
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- Registered title, and
- Data storage requirements.

Ethics statement

The highest ethical standards were maintained in this thesis. The ethical considerations for this study are discussed in detail in Section 3.6.

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Abstract

This study investigated the factors that influence South African mathematics teachers' integrating of ICTs into their classroom practices. Guided by three research questions namely: What ICTs are being implemented in mathematics teachers' classrooms? How are the ICTs being implemented in the teaching and learning environment? Why are mathematics teachers' implementing ICT in their classrooms? A quantitative post-positivist research design was used and 191 responses were captured.

The top three ICTs available to participating teachers included: Personal Computer/Laptop, Microsoft Word and E-Mail. How participating teachers integrated ICT was broken up into two parts with the first part divided into three sub-categories. The top ten of each category was identified and noticeably all of them could be related back to educational functionality. In the second part a total of 278 ICTs were identified and were later categorised into twenty categories. The ICT perceived to have the biggest impact on the teaching and learning of mathematics was a data projector. Further investigation along the SAMR model indicated that the substitution category was by far the largest with 71.70% falling within this category. A further 23.90% were integrating ICTs at the Augmentation level, 1.89% at the modification level and 0% at the redefinition level.

Why participating teachers integrate ICT was investigated using the four constructs (Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions, Behavioural Intention) of the UTAUT framework. The four constructs were hypothesised to influence teachers' use of ICTs within the educational domain. Results from Structural Equation Modelling (SEM) indicated that three of the four constructs were statistically significant.

Key Terms:

Education, ICT integration; Technology acceptance; Unified Theory of Acceptance and Use of Technology; UTAUT, SAMR, Mathematics education

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TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled ***"The integration of ICT by Mathematics teachers in the classroom"*** by Ruan Kapp was proof read and edited by me in respect of language.

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List of abbreviations

AECT	Association for Educational Communication and Technology
AMOS	Analysis of Moment Structures
ANA	Annual National Assessment
BECTA	The British Educational Communications and Technology Agency
BI	Behavioural intention
BYOD	Bring Your Own Device
CAPS	Curriculum and Assessment Policy Statement
CAS	Computer Algebra Systems
CFA	Confirmatory Factor Analysis
C-TAM-TPB	Combined Theory of Planned Behaviour / Technology Acceptance Model
DBE	Department of Basic Education
DGS	Dynamic Geometry Software
DTPB	Decomposed Theory of Planned Behaviour
EE	Effort Expectancy
EFA	Exploratory Factor Analysis
FC	Facilitating Condition
GDE	Gauteng Department of Education
KMO	Kaiser-Meyer-Olkin
ICT	Information and communications technology
IDT/DOI	Innovation Diffusion Theory
IEA	International Association for the Evaluation of Educational Achievement's
ISTE	International Society for Technology Education

IT	Information Technology
MM	Motivational Model
MPCU	Model of PC Utilization
MTEF	Medium Term Expenditure Framework
NETS-S	National Educational Technology Standards for Students
NCTM	National Council of Teachers of Mathematics
OECD	Organisation for Economic Cooperation and Development
PDF	Portable document format
PDOE	Provincial Departments of Education
PE	Performance Expectancy
PISA	Programme for International Student Assessment
PWS	Personal Work Station
SAMR	Substitution, Augmentation, Modification, Redefinition
SCT	Social Cognitive Theory
SEAMEO	Southeast Asian Ministers of Education Organization
SEM	Structural Equation Modeling
SI	Social Influence
SIIA	Software and Information Industry Association
SITES	Second Information in Technology in Education Study
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptance Model
TIM	Technology Integration Matrix
TIMSS	Trends in International Mathematics and Science Study
TPB	Theory of Planned Behaviour

TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology

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1. CHAPTER 1: GENERAL ORIENTATION

1.1 INTRODUCTION

There has been exponential growth in the use and interest of information and communications technology (ICT) during the past decade. Anderson (2010) believes that ICT now affects all spheres of our daily lives, so much so that it has become a compulsory tool for the normal functioning of modern society. It is therefore not surprising to find increasing attention and investment being funnelled into the utilisation of ICT in education all over the world. Several interventions on ICT implementation in education has been produced in many countries (Pelgrum & Anderson, 1999; Wong, Li, Choi & Lee, 2008).

The South African government, in keeping up with international trends, introduced the white paper on e-Education policy (Department of Basic Education [DBE], 2004). This policy was introduced with the intention to change teacher pedagogy and learner achievements using ICT (DBE, 2004). Implementation of this e-Education policy however rests with the Provincial Departments of Education (PDOE). The Gauteng Department of Education (GDE) has invested over R800 million in E-learning in the 2015/16 financial year with a projected R2 billion over the 2015 Medium Term Expenditure Framework (MTEF) period (Gauteng Department of Education [GDE], 2015). However, according to the ‘Action plan 2019’ document, published by the National Department of Education, there is still a major weakness in the system when it comes to the implementation of ICT to improve the teaching and learning process (DBE, 2015). The ‘Action plan 2019’ document states: “The area is a difficult one because the evidence is not very clear on, for instance, what ICT investments are best for improving learning and teaching” (DBE, 2015, p. 14).

It is therefore crucial that research be done, to understand what ICTs teachers use, how they apply these technologies and why they opt to make use of the specific technologies. It could lead to a better understanding of what to spend educational investments on.

1.2 PROBLEM STATEMENT

South Africa has one of the most underperforming school systems in the world. The latest World Economic Forum Global Competitiveness report for 2015-2016 shows the country ranked 138 out of 140 countries for the overall quality of the education system (Schwab, 2015). South Africa's quality of mathematics and science education is also underperforming compared to the rest of the world. The Trends in International Mathematics and Science Study (TIMSS) is an international assessment of grade 8 learners' mathematics and science content knowledge. TIMSS is administered every 4th year and in 2003 South Africa was listed last in the last position for mathematics education. For 2007 there were no results as South Africa did not participate in the study and in 2011 as well as 2015 South Africa improved to take up second last place, but bearing in mind that the tests were administered to grade 9 learners (Reddy et al., 2012; Reddy et al., 2016). The poor achievement in mathematics is also evident from the Annual National Assessment (ANA) results achieved over the last few years. In 2014 the ANA Grade 9 average for mathematics was 10.9% (DBE, 2014).

Considering this situation and in search of a viable solution, ICT is often perceived as a feasible answer. According to Birch (2009) learners are more motivated to learn when ICT is used in the classroom since it relates to their interests and way of life. It could therefore be argued that more monetary resources should be invested in ICT infrastructure and that teachers should re-evaluate their methods of teaching and learning by utilising resources such as ICTs. However, in South Africa the incorporation of ICT into the classroom environment is very limited. Using data from the International Association for the Evaluation of Educational Achievement's (IEA) Second Information in Technology in Education Study 2006 (SITES), Howie and Blignaut (2009) reported that merely 18% of teachers teaching Grade 8 mathematics used ICT in their classrooms. The main use of ICT according to the SITES data was for administrative tasks and secondly for monitoring learner's feedback. The integration of ICT into classroom practice was still lower, with only 46% of mathematics teachers responding to questions on their frequency of ICT use, of which 5% indicated that they use ICT once a week and an additional 5% of teachers indicated that they use ICT rigorously for a limited time (Howie & Blignaut, 2009).

Laudon and Laudon (2010) furthermore caution that a significant investment in ICT does not necessarily guarantee higher returns. It is important that we place educational principles first when confronted with this 'hype' around what certain products and software can do for our education system. Although research has shown that ICTs can be applied effectively as a tool for teaching and learning (Bransford, Brown & Cocking, 2000; Bruce & Levin, 2003), it also advises that the integration of ICTs can be a complex and challenging process for schools (Wilson-Strydom, Thomson & Hodgekinson-Williams, 2005). The objective for applying any new ICT in the teaching and learning environment should always be to support and enhance effective education (Brás, Miranda & Marôco, 2014; Loveless & Ellis, 2003).

According to the Department of Basic Education's Action plan 2019 a big concern is the little research on how schools are currently making use of ICTs. Howie and Blignaut (2009) points out that South Africa is relatively new to the studying and implementing ICT in education. The purpose of this research is therefore to add to the little research available by investigating what, how and why ICTs are being used by mathematics teachers across South Africa's schools.

1.3 AIMS OF THE RESEARCH

The main aims of this research project are:

- To develop a list of what ICTs mathematics teachers integrate into their teaching and learning.

- To establish how mathematics teachers use ICTs in teaching and learning of mathematics at school level.

- To gain a deeper understanding as to why mathematics teachers integrate ICTs.

- To determine if there is a link between how mathematics teachers integrate ICTs and why they opt to do so.

- It was also envisaged that the research findings would make a contribution towards the better understanding of what to spend educational investments on.

1.4 PURPOSE OF THE RESEARCH

I have always had two passions in life: teaching and technology. I graduated in 2011 majoring in mathematics education. Entering the teaching profession in 2012, I quickly adopted multiple ICTs to enhance my teaching, realising that ICT can be used as an influential educational tool for exploring different topics within the mathematics curriculum.

ICTs incorporated in my teaching included the likes of GeoGebra, Edmodo, an interactive whiteboard and videos. Being a young and passionate mathematics teacher I advocated the use of ICT amongst my colleagues, offering training and support. Yet by the time I exited teaching three years later some teachers embraced and adopted ICT whilst many were still using the traditional “talk and chalk”. This created a curiosity in me, wanting to know what technologies worked best for mathematics teaching and why some teachers embraced the use of ICT, whilst others resisted it.

My current occupation is in the professional development of teachers. I do training and present workshops to in-service teachers across South Africa on utilising ICTs for their classrooms. These include the use of software packages such as Microsoft Office, GeoGebra and video applications for creating educational videos that can be integrated into teaching. My work affords me the ability to conduct research amongst in-service mathematics teachers. I wish to use this opportunity to build an understanding of the complex, and context-situated nature of mathematics teachers’ ICT adoption in their teaching. I hope my research will complement the small amount of research available for developing countries and deepen the current knowledge of ICT adoption in mathematics education in South Africa.

1.5 RESEARCH QUESTIONS UNDER INVESTIGATION

1.5.1 Primary research question:

What are the factors influencing mathematics teachers' integration of ICTs into their classrooms?

1.5.2 Secondary research questions:

- Question 1: What available ICTs are being integrated by mathematics teachers into their teaching?
- Question 2: How are the ICTs being integrated in the teaching and learning process?
- Question 3: Why are mathematics teachers integrating ICTs in their classrooms?

1.6 RESEARCH DESIGN AND APPROACH

This study was conducted within the post-positivist paradigm (Guba & Lincoln, 2005; Mertens, 2014; Trochim, 2006b) and underpinned by a critical realist world view (Benton & Craib, 2010; Sayer, 2000; Wikgren, 2005). Quantitative data gathering methods were utilised which included a survey in both hard copy as well as electronic form (Google Forms). The questionnaire comprised of Likert scale questions, as well as open-ended questions (Flick, 2007, 2014; Johnson & Christensen, 2008).

1.7 POPULATION AND SAMPLING

1.7.1 Population

The population of a sample refers to the participants of the study with whom the research problem is concerned (Field, 2014, p. 42). Gray (2009) defines a population as the entire number of possible groups or elements that the researcher wishes to include in the research. For this study, the population included in-service mathematics teachers from across South Africa, teaching Grades 1 to 12. However, it should be noted that whilst an attempt was made to distribute the e-survey link across South Africa, using various email lists obtained by the researcher. The respondents came predominantly from city schools where ICTs are readily available, especially in the two provinces namely Gauteng and the Western Cape as these two provinces both have intensive focus on ICT with various ICT implementation plans.

1.7.2 Sampling

Sampling refers to the process used to select a portion of the population for the study (Maree, 2007). The main purpose of sampling according to Nieuwenhuis (2013) is to collect the best (richest) data that will answer the study's question(s). For this study, purposive sampling was utilised, because the sample set shared a common attribute i.e. all of the participants were in-service mathematics teachers. Patton (2002) explains that in purposive sampling, the sample is purposefully selected from those individuals who have experience with the studied phenomenon.

1.8 DATA COLLECTION

To obtain as large a response as possible, the use of both hard copy questionnaires as well as an online survey were utilised. Hard copies were handed out at professional development sessions that teachers attended, whilst the link to the e-survey was sent electronically to teachers. In total 191 teachers completed the questionnaires (either online via the e-survey or a hard copy of the same questionnaire).

1.9 DATA ANALYSIS

The Statistical Package for the Social Sciences (SPSS) version 24 software and its supplement, Analysis of Moment Structures (AMOS) version 24, were found to be the appropriate and the most suitable tools for analysing the quantitative data in this study. Data screening measures were used to ensure accuracy and usefulness of the data. After that, an exploratory factor analysis was carried out to investigate the underlying structure. This also allowed for reliability and validity testing of the model. A confirmatory factor analysis followed and a measurement model was developed. Reliability and validity tests were also revisited during the confirmatory factor analysis stage. Finally, Structural Equation Modeling (SEM) was employed to answer four hypotheses drawn from the literature, the Exploratory Factor Analysis (EFA) and the Confirmatory Factor Analysis (CFA).

1.10 VALIDITY

For this study construct validity in the form of convergent validity and discriminant validity was inspected (Drost, 2011; Trochim, 2006a). Convergent validity indicates the degree to which items correlate highly, if those items hypothetically belongs to a construct. On the other hand, discriminant validity indicates the degree to which items or measures of a scale do not measure other constructs.

1.11 RELIABILITY

Reliability according to Cohen, Manion and Morrison (2011) is synonymous with dependability, consistency and replicability over time. This implies that comparable findings must be the result if research were performed on comparable groups of respondents in a comparable context. For this study, the Cronbach's Alpha (Field, 2014, p. 708) was used to check the questionnaire's reliability by evaluating the internal consistency of the items for all four constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT).

1.12 ETHICAL CONSIDERATIONS

Every research aims to adhere to a strict code of conduct, hold to some core principles and finally aims to contribute to the body of knowledge (Resnik, 2015). In addressing Terrell's (2012) list of ethical concerns, the researcher created an online questionnaire (Google form) with a first page explaining the purpose and modus operandi of this study. Participating teachers could only continue to the next part of the online questionnaire (e-survey) if they agreed to participate, making participation completely voluntary. Additionally, participating teachers were not allowed to continue with the online questionnaire if they did not select a checkbox to indicating that they had read and understood that participation is voluntary and anonymous. Likewise, to the online questionnaire, respondents completing the hard copies of the questionnaires, distributed at the mathematics seminar or conference, signed an informed consent letter attached to the questionnaire.

1.13 RESEARCH STRUCTURE

To assure a well-structured research report in which the content flows in a logical order and in which the research aims and questions are addressed, the chapters were outlined as follows:

Chapter 2: Literature review

This chapter lays out the literature review and the theoretic framework of the study. The idea of ICT in education is discussed in full, paying specific attention to what effects ICT has on the teaching and learning environment, why implementing ICT in mathematics teaching and learning is beneficial as well as the different integration models available in the literature. Furthermore, the factors or barriers for the integration of ICT in the teaching and learning of mathematics (resources, knowledge and skills of teachers, institutional barriers, attitudes and beliefs of teachers, assessment, subject culture and internal and external factors), are discussed. For the conceptual framework, the Unified Theory of Acceptance and Use of Technology (UTAUT) model combined with the Substitution, Augmentation, Modification and Redefinition (SAMR) model was selected. The four main constructs of the UTAUT model, namely Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) together with the SAMR model and its four stages (Substitution, Augmentation, Modification and Redefinition) are discussed in full in this chapter.

Chapter 3: Research methods

In this chapter, the focus is on important aspects of the research methodology. The utilisation of a post-positivistic critical realist paradigm as the worldview of this study is discussed. In line with the aforementioned the use of a quantitative approach to best answer the research questions are justified and discussed. Thereafter the research methods, including the sample and study participants, the participant profile, data collection strategies, surveys as instrument and data analysis procedures for quantitative data analysis, are discussed. Next the validity and reliability issues for quantitative research are discussed and finally ethical issues are considered.

Chapter 4: Findings

In Chapter 4 the results of the study are discussed along the layout of sections in the questionnaire. Section A of the questionnaire captured the demographic information as well as some background questions such as age, gender and years' teaching experience etc. Section B of the questionnaire focused on the integration of ICTs in teaching and learning and identified the top ten ICTs available to participating teachers. How these ICTs are utilised within the educational domain are discussed along the SAMR integration model captured in Section D of the questionnaire. Section C of the questionnaire focuses on identifying the factors as to why teachers integrate ICT into the teaching and learning of mathematics. The four constructs of the UTAUT framework (Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions) are hypothesised to influence teachers' use of ICTs within the educational domain. The results of an EFA and a CFA is discussed and used to draw up four hypotheses namely:

Hypothesis 1:
H_0: Performance expectancy (PE) has no significant effect on behavioural intention (BI).
H_a: Performance expectancy (PE) has a significant effect on behavioural intention (BI).

Hypothesis 2:

H_0: Effort expectancy (EE) has a no significant effect on behavioural intention (BI).

H_a: Effort expectancy (EE) has a significant effect on behavioural intention (BI).

Hypothesis 3:

H_0: Social influence (SI) has no significant effect on behavioural intention (BI).

H_a: Social influence (SI) has a significant effect on behavioural intention (BI).

Hypothesis 4:

H_0: Behavioural intention (BI) has no significant effect on the use (USE).

H_a: Behavioural intention (BI) has a significant effect on the use (USE).

Finally, the results of the Structural Equation Model (SEM) used to test the four hypotheses are then discussed.

Chapter 5: Discussion on findings

In Chapter Five a discussion on the findings, along the three research questions, follow. Insights and conclusions are drawn from the results of the study and implications relating to this the study are also stated. Furthermore, some recommendations are made and possible future research to be conducted is pointed out.

1.14 CHAPTER SUMMARY

In Chapter 1, an introduction is given to the study as well as the problem statement. According to Anderson (2010) there has been exponential growth in the use and interest of ICT during the past decade. Increasing attention and money are being funnelled into the utilisation of ICT in education all over the world and especially in developing countries. Yet, according to Sime and Priestley (2005) teachers are not utilising ICT optimally in their classrooms. South Africa is no exception in this regard as Howie and Blignaut (2009) found that the ICT integration of mathematics teachers in South Africa is also very low. The question that therefore arises is: If ICT is so commonly available and used among our learners, why don’t South African mathematics teachers harness the benefits that ICT brings to the educational domain?

2. CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The available literature on ICT in education is explored in this chapter, with a specific emphasis on mathematics education. The literature review begins with an overview of what ICT in the education domain is, as well as its effects and integration models. An in-depth analysis on the role of ICT in mathematics education follows and afterwards the factors that influence the use of ICTs are examined to create a holistic picture of ICT in education. Lastly the conceptual framework underpinning this study is discussed and linked to the literature.

2.2 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION

To investigate how ICT is used in education and especially in the teaching and learning of mathematics, one must have a clear understanding of what is meant by the term ICT. Moursund (2003) provides a comprehensive and detailed definition of ICT on his webpage as follows:

> ICT includes the full range of computer hardware, computer software, and telecommunications facilities. Thus, it includes computing devices ranging from handheld calculators to super computers. It includes the full range of display and projection devices used to view computer output. It includes the local area networks and wide area networks that allow computer systems and people to communicate with each other. It includes digital cameras, computer games, CDs, DVDs, cellular telephones, telecommunication satellites, and fibre optics. It includes computerised machinery, and computerised robots. (Moursund, 2003)

ICT has been defined and redefined from various perspectives over the last few years. According to Anderson (2010), Lundall and Howell (2000) and Pita (2010) ICT could also be termed as the "merging of all the uses of an array of technologies that enable individuals, organisations, businesses and schools to access, use, store, create, retrieve, transmit, exchange and communicate information anytime and anywhere in the world". Draper (2011, p24) defines ICT as referring to "all technologies used for processing information and for communicating". According to Draper (2011) information technology (IT), computer technology and ICT are regularly used interchangeably and may refer to the same thing. In the white paper published on e-education (DoE, 2004), South Africa however makes a clear distinction between IT and ICT. The white paper defines ICT as the combination of both IT (hardware and software) and communication technology, allowing the processing, handling and exchanging of data, information and knowledge, thereby increasing what is humanly possible. In some countries, the terms 'educational technology' and ICT are used synonymously. Downes et al. (2003) on the other hand states that it is a much larger term and it is therefore useful to make the distinction that is made in a report for Southeast Asian Ministers of Education Organization (SEAMEO): "The term educational technology frequently includes many other forms of accessing, presenting, or communicating information, such as projector equipment and video and audio technologies including distance education formats such as radio and television." (Downes et al., 2003, p. 13).

The Association for Educational Communication and Technology (AECT) in the United States of America is concerned with standardising definitions of ICT for education (Anekwe & Williams, 2014). The Board of Directors of the AECT has endorsed a definition (and the sixth since 1963) of ICT (Richey, Silber, & Ely, 2008). A definition by Januszewski and Molenda (as cited in Richey et al., 2008, p. 24) reads as follows: ICT in education "is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources". In this definition, instructional design is downplayed but not ignored and current understanding of the learning process is considered (Richey et al., 2008). Facilitating learning implies the supplying and arrangement of resources and tools in such a way that learning is meaningful instead of superficial while also assessing the performance (Anekwe & Williams, 2014).

In brief the term ICT in education, is described by Khan, Hossain, Hasan and Clement (2012) as: “those technologies including computers, the Internet, telephony, and broadcasting technologies (radio and television) that can facilitate not only delivery of instruction, but also learning processes itself”. Watson and Watson (2011) state that the technologies described here have been recognised as important tools for creating and attaining a learner-centred education environment. The term ICT will be used in this study to refer to technology or educational technology as the combination of hardware and software utilised by mathematics teachers for teaching and learning.

2.3 UTILISING ICT WITHIN THE TEACHING AND LEARNING ENVIRONMENT

From the previous section the term ICT and its definitions were discussed within the educational domain. The following section discusses the effects of implementing ICT in education as well as some implementation models. Furthermore, progress and associated problems concerning the use of ICT in education are discussed.

2.3.1 Effects of ICT on the teaching and learning environment

The integration of ICT in education has become a significant topic as ICTs have undoubtedly affected teaching, learning and research within this domain (Drent & Meelissen, 2008; Yusuf, 2005). Findings of the research have provided some evidence that indicates positive effects for the integration of ICT into the teaching and learning environment (Al-Ansari, 2006; Hattie, 2009; Mumtaz, 2000). According to Sanyal (2001) “there are four ways, ICT can support education and they are: 1) supporting education in schools; 2) providing non-formal education for out-of-school children and adults; 3) supporting pre-service distance education of teachers and their in-service professional development and 4) enhancing the management of schools”.

Hawkridge, Jawoski and McMohan (1990) support this claim, advocating that integration of ICTs might increase administration, teaching and overall performance, thus impacting al spheres of the education system positively. Researchers Davis and Tearle (1998) and Lemke and Coughlin (1998), as cited in Yusuf (2005), also concur stating that “ICTs have the potential to innovate, accelerate, enrich, and deepen skills, to motivate and engage students, to help relate school experience to work practices, create economic viability for tomorrow's workers, as well as strengthening teaching and helping schools change”. Figure 2.1 below, the results of a national survey conducted by PBS media in 2013, shows the benefits of educational technology as perceived by K-12 teachers in the United Stated of America.

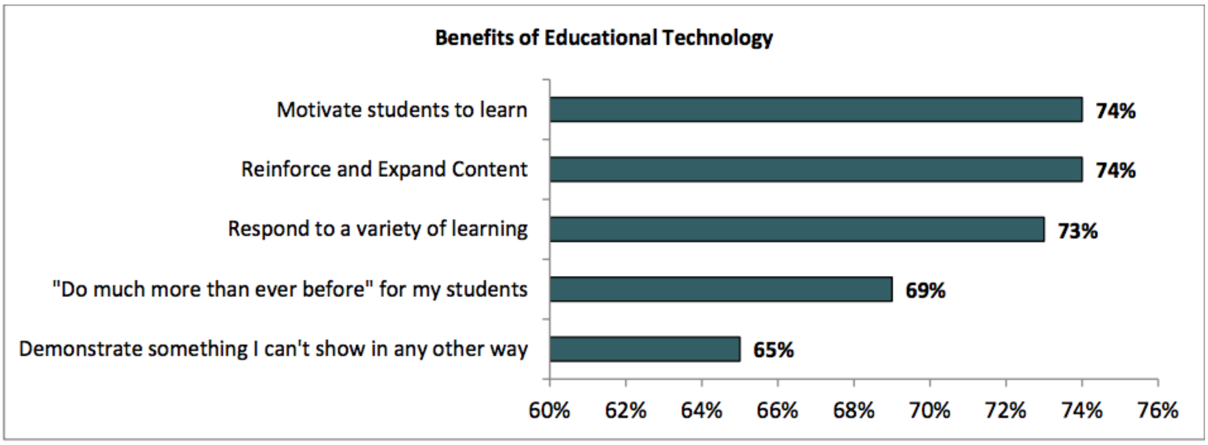

Figure 2.1: Benefits of educational technology (Hanover Research, 2013)

The benefits of ICTs have led to schools, in developed countries, investing enormously over the last twenty years in ICT infrastructures. According to Volman (2005) “learners use ICT now more often and for a much larger range of applications than ever before”. Research among the developing countries indicates that learners using ICT facilities generally show higher learning gains than those who do not use it (Kulik, 1994). Underwood (2009) also confirms that there is mounting data to support the array of benefits arising from the use of ICT in education. Condie and Munro (2007) note that research points to an increase in achievement where ICTs are integrated as part of the everyday learning experiences of pupils, however, they also caution that the evidence is lacking to a draw definite conclusion. Furthermore, a study of the Programme for International

Student Assessment (PISA) tests found that "learners who occasionally use ICTs such as computers or the internet at school, perform better than those who never use them". In contrast, the data also reveals that learners who use them often may perform worse. Fuchs and Woessmann (2004, p. 24) state the following:

> A positive correlation between student achievement and the availability of computers both at home and at schools. However, once we control extensively for family background and school characteristics, the relationship gets negative for home computers and insignificant for school computers. Thus, the mere availability of computers at home seems to distract students from effective learning. (Fuchs & Woessmann, 2004, p. 24)

Herselman (2003) points out that ICT holds advantages for both teacher and learner. Kozma and Anderson (2002) describe some of these advantages as: "promoting active and independent learning and breaking down gender, language, communication and social-cultural barriers". The integration of ICT into education consequently helps learners develop vital 21st century skills like searching, analysing and communicating information.

For teachers, ICT is also making an impact on pedagogy. Bush and Mott (2009) and Reigeluth et al. (2008) found the following components to have a direct influence on pedagogigal approaches in the classroom: "providing interactive content, giving immediate feedback, diagnosing student needs, providing effective remediation, assessing learning, and storing examples of student work (e.g. portfolios)". All of these mentioned are all elements made possible, by incorporating ICT into the teaching and learning environment. For professional development of teachers there is a range of ICTs that can promote international collaboration and networking. The Digital Education Enhancement Programme, a research study, carried out in twelve primary schools in rural, disadvantaged areas of South Africa reports that ICT use enhances teachers' professional knowledge and capabilities (Leach, 2008; Leach, Ahmed, Makalima & Power, 2005). Lifelong learning can therefore be aided by ICT as it provides flexible and effective ways for conducting professional development.

Watson (2001) also notes that ICTs have changed the future of the workforce and are now transforming our education systems. Indicative of this is the fact that, if our schools train children in yesterday's skills and technologies the possibility exists that they may not be effective and fit for tomorrow's world. This implies that ICTs have changed the landscape of the modern-day classroom and in return became a fundamental teaching tool and resource, which in its own places a new expectancy on teachers to incorporate ICTs in the teaching and learning environment.

However, according to the Gauteng Provincial Department of Education, the teacher remains the one central factor for successful use of ICT tools within the educational domain (GDE, 2015). Therefore, the true potential of ICT is attained when outstanding pedagogical practises are met with quality ICT integration. Kadiyala and Crynes (2000) in their research also found compelling support that ICT could improve teaching and learning if the pedagogy is sound and if ICT, techniques and objectives are well-matched. Ringstaff and Kelley (2002) also explain that ICT is merely an instrument for reaching teaching and learning goals and should not be the goal in itself. According to Brás et al. (2014) and Loveless and Ellis (2003), the objective for applying any new ICT into the teaching and learning environment, at its highest priority, should always be to enhance already effective education. As Spector, Merrill, Elen and Bishop (2014) state "the integration of ICT into the classrooms should always be about what new technologies could do to support learners understanding".

2.3.2 Models for integration of ICT into the teaching and learning environments

Seeing that ICT undoubtedly affects the teaching and learning environment, methods or approaches in education, should be investigated to integrate ICT into education. The International Society for Technology in Education's (ISTE) National Educational Technology Standards for Students (NETS-S) defines technology integration on their website as follows:

> Effective integration of technology is achieved when students are able to select technology tools to help them obtain information in a timely manner, analyse and synthesise the information, and present it professionally. The technology should become an integral part of how the classroom functions - as accessible as all other classroom tools. (International Society for Technology in Education [ISTE], 2016)

The successful integration of ICT relies on many technology components and resources to achieve improved student learning outcomes (Hanover Research, 2013). Research from the Hanover Research company points out that education departments, districts and schools should aim for technology integration that is routine and transparent, accessible, and supportive of curricular goals (Hanover Research, 2013). When these factors are present, technology tools become a seamless part of the learning process. Anekwe and Williams (2014) provide a list of objectives of ICT in terms of teaching in the classroom:

- Classify and scrutinise learners' traits and educational requirements.
- Shaping classroom goals and declaring them in terms of behaviour.
- Investigating the substance of instruction and putting it in an appropriate order.
- Recognising obtainable teaching and learning materials.
- Getting familiarised with the type of learner and teacher interactions.
- Assessing the efficiency of instruction in the classroom in terms of learner achievement.
- Offering suitable assessment to both learners and teachers for adapting the teaching-learning method as needed.

Two technology integration models, the Technology Integration Matrix (TIM) and SAMR (Substitution, Augmentation, Modification, Redefinition) can help teachers to adopt ICT in the educational environment. While the latter is based on four phases of integration, the Technology Integration Matrix relies on five levels of integration and couples these with different learning environments (active, collaborative, constructive, authentic, and goal directed). The TIM is discussed below, while the SAMR will be discussed in full under Section 2.6 as it forms part of the study's conceptual framework.

2.3.2.1 Technology Integration Matrix (TIM)

The TIM serves as a model for technology integration as well as an evaluation matrix. Jonassen, Howland, Moore and Marra (2003) explain that "the model uses five levels of technology integration (entry, adoption, adaptation, infusion, and transformation) as well as five learning environments (active, collaborative, constructive, authentic, and goal directed)". This then yields a matrix of 25 possible combinations.

The TIM proceeds in five unique stages from entry to transformation. These five levels of integration are defined below:

- Entry: Curriculum content is delivered, by the teacher, through the use of ICTs to learners.
- Adoption: Learners are directed by the teacher to use conventional tool-based software. If such software is available, this level is recommended.
- Adaptation: Learners are encouraged and motivated to use tool-based software. The teacher allows learners to select a tool and adapt it in such a way that the task involved can be accomplished.
- Infusion: Learners are continually provided with opportunities to use ICTs with understanding, applying, analysing, and evaluating the tasks involved.
- Transformation: An encouraging and rich teaching and learning environment is created by the teacher. Learners are given the open choice of ICT tools to use with student-initiated investigations, discussions, compositions, or projects, across any content area, being promoted.

Table 2.1, from the Arizona K12 centre website, illustrates the Technology Integration Matrix in its full view and defines each learning environment with the technology integration combination.

Table 2.1: Technology Integration Matrix as copied from (Arizona K12 Center, 2012)

Levels of Technology Integration into the Curriculum →

Characteristics of the Learning Environment ↓

Technology Integration Matrix	**Entry** Teacher uses technology to deliver curriculum content to students.	**Adoption** Teacher directs students in the conventional use of tool-based software. If such software is available, this level is recommended.	**Adaptation** Teacher encourages adaptation of tool-based software by allowing students to select and modify a tool to accomplish a task at hand.	**Infusion** Teacher consistently provides the infusion of technology tools with understanding, applying, analyzing and evaluating learning tasks.	**Transformation** Teacher cultivates a rich learning environment, where blending choice technology tools with student-initiated investigations, discussions, compositions, or projects, across any content area, is promoted.
Active Students are actively engaged in educational activities where technology is a transparent tool used to generate and accomplish objectives and learning.	**Active: Entry** Students receive content through the use of technology, or use technology for drill and practice type activities.	**Active: Adoption** Students occasionally use specified technology tools to plan or create end products.	**Active: Adaptation** Students choose or modify the technology-related tools most appropriate for developing learning tasks.	**Active: Infusion** Students focus on learning tasks, and purposefully combine technology tools to design desired outcomes based on their own ideas.	**Active: Transformation** Students seamlessly organize the learning tasks and formulate products, discussions, or investigations using the appropriate technologies available.
Collaborative Students use technology tools to collaborate with others.	**Collaborative: Entry** Students primarily work alone in highly structured activities, using technology.	**Collaborative: Adoption** Students are allowed the opportunities to utilize collaborative tools in conventional ways.	**Collaborative: Adaptation** Students have opportunities to select and employ technology tools to facilitate and enhance collaborative work.	**Collaborative: Infusion** Students select technology tools to facilitate and enhance collaboration in all aspects of their learning.	**Collaborative: Transformation** Students seamlessly use technology tools to globally collaborate with peers and experts.
Constructive Students use technology to understand content and add meaning to their learning.	**Constructive: Entry** Technology used to deliver information to students.	**Constructive: Adoption** Students begin to use constructive technology tools to build upon prior knowledge and construct meaning.	**Constructive: Adaptation** Students have opportunities to choose and manipulate technology tools to assist them in molding their understanding.	**Constructive: Infusion** Students make connections with technology tools to construct deeper understanding across disciplines.	**Constructive: Transformation** Students use technology to construct, share, and publish new knowledge to an appropriate audience.
Authentic Students use technology to solve real-world problems meaningful to them, such as digital citizenship.	**Authentic: Entry** Students use technology to complete assigned activities that are generally unrelated to real-world problems.	**Authentic: Adoption** Students are allowed opportunities to employ technology tools to connect content-specific activities that are based on real-world problems.	**Authentic: Adaptation** Students have opportunities to select and utilize the appropriate technology tools and digital resources to solve problems based on real-world issues.	**Authentic: Infusion** Students select appropriate technology tools to complete authentic tasks across disciplines while modeling digital etiquette and responsible social interactions.	**Authentic: Transformation** Students participate in meaningful projects that require problem-solving strategies, and facilitate global awareness, through the utilization of technology tools.
Goal Directed Students use technology tools to research data, set goals, plan activities, monitor progress, and evaluate results.	**Goal Directed: Entry** Students receive directions, guidance, and feedback from technology, rather than using technology tools to set goals, plan activities, monitor, or evaluate an activity.	**Goal Directed: Adoption** From time to time, students have the opportunity to use technology to either plan, monitor, or evaluate an activity.	**Goal Directed: Adaptation** Students have opportunities to select and modify the use of technology tools to facilitate goal-setting, planning, monitoring, and/or evaluating specific activities.	**Goal Directed: Infusion** Students use technology tools to set goals, plan activities, monitor progress, and evaluate results throughout the curriculum.	**Goal Directed: Transformation** Students engage in ongoing meta-cognitive activities, with reflection or connected purpose, supported by technology tools.

Source: Technology Integration Matrix as copied from (Arizona K12 Center, 2012)

2.3.3 Prevalence of ICT integration in education

Despite ICT being increasingly available to learners, teachers are not using it optimally in their classrooms. Sime and Priestley (2005) states that “although teachers in schools show great interest and motivation to learn about the potential of ICT, in practice, use of ICT is relatively low and it is focused on a narrow range of applications”. Vrasidas and Glass (2005) found that even when computers are available, teachers do not use them as expected. The 2015 Software and Information Industry Association (SIIA) K-20 survey, which was administered to nearly 930 K-12 teachers in the United States of America, gave some insights into teacher’s actual integration of ICTs. In the survey 76% of the respondents described their ideal level of technology integration as “high”, but only 23% felt they had achieved this ideal level. This indicates that most teachers desire for greater technology integration, but that actual integration remains very low. The “Learning to change” report, published by the Organisation for Economic Cooperation and Development (OECD) in 2001, described how ICTs were being used in the developed countries. The report concluded that ICT was merely used to do conventional things in different ways. Examples included: "putting on screen what can be found on the page of a book, using material from the Internet to support conventional teaching practices, and employing didactic software to rehearse basic skills.” This indicates that ICTs are merely used to replicate existing learning methods in a technological form.

South Africa, according to Howie and Blignaut (2009) is a relative newcomer to both studying and implementing of ICT in education. In their research, Howie and Blignaut (2009) found that, although only for mathematics and science teachers, the integration of ICT was very low. Howie and Blignaut (2009) reported that only 18% of Grade 8 mathematics teachers and 16% of Grade 8 science teachers used ICTs in teaching and learning activities. The main use of ICTs, according to the study was for administration purposes and secondly for monitoring learner’s feedback. Cohen (2003), in a study on ICT use in South Africa, also found that the most fundamental usage of computers in schools was for administration purposes.
Haddad (2007) states that:

> If technology-enhanced education programs are taped classrooms, digital texts, and PowerPoint transparencies, then we are missing the tremendous potential of technologies that can animate, simulate, capture reality, add movement to static concepts, and extend our touch to the whole universe. (Haddad, 2007, p. 11)

It is therefore important to point out that if ICTs in education are to fulfil their potential, innovation and change is needed at all levels of the school environment. Supplying schools with ICTs alone, is not enough for improving the teaching and learning in the classroom. Research into how teachers use ICTs are therefore fundamental, as it could help governments and teacher training providers to tailor courses specifically for increasing pedagogical use of ICTs.

2.4 INFORMATION AND COMMUNICATION TECHNOLOGIES IN MATHEMATICS EDUCATION

According to researchers Kaput and Roschelle (1997) the potential of ICTs for improving the teaching and learning of school mathematics is immense. However, it is only in Britain, United States of America, Singapore, Canada, Hong Kong and Korea that the study of computer usage has shown a noticeable increase in education (Ruthven & Hennessy, 2002). Ruthven and Hennessey (2002) further explain that for most other countries usage remains low and growth is very slow. According to Brown et al. (2005) the use of ICT in mathematics should emphasise employing ICT to meet the needs of the learners in mathematics and not teaching technology skills, as the technology is supposed to support mathematics teaching. It is however important to stress that ICT skills are needed to manipulate available ICT resources. Thus, a balance should be struck between ICT integration in teaching and learning and ICT literacy.

2.4.1 Why implement Information and Communication technology in mathematics education

According to Wilson (2000) the appropriate uses of ICT tools can effectively improve mathematics teaching and learning, support conceptual development amongst learners, enable mathematical investigations and influence how mathematics is taught and learnt. A pan-European literature review by Balanskat, Blamire and Kefala (2006) indicated that, in OECD countries there is a positive correlation between the time ICTs are used and learners' performance in the PISA mathematics tests. Internet usage in educational spaces in particular, resulted in noteworthy improvement in learners' performances. Interactive whiteboards are also one of the ICTs linked with increases in learners' performance, particularly for low-achieving pupils in English and mathematics.

In 2003 the British Educational Communications and Technology Agency (BECTA) summarised some key benefits of integrating ICT in mathematics education to be: 1) Promoting greater participation among learners and encouraging communication and the sharing of knowledge; 2) Enabling the educator to provide prompt and accurate feedback to learners and thus contributing towards positive motivation and 3) ICT also allows learners to move away from tedious computational calculations to focus more on strategies and the interpretations of answers.

This is further emphasised by Kerrigan (as cited in Mistretta, 2005) who also found that integrating computers in mathematics classrooms promotes learners' higher order thinking skills and facilitates learners' algebraic and geometric thinking, leading to learners exploring problem-based learning.

This emphasises the important fact that ICT also supports a constructivist pedagogy, meaning that learners can use ICTs to build an understanding of mathematical concepts by exploring and applying problem-solving skills. According to the National Council of Teachers of Mathematics (NCTM) this method encourages higher order thinking skills and is in line with their recommendations stating that "learners would use technology to concentrate on problem-solving processes rather than on calculations related to the problems" (Ittigson & Zewe, 2003).

2.4.2 Procedural versus conceptual mathematics

Researchers Artigue (2002), Hoyles, Noss and Kent (2004) and Zbiek, Heid, Blume and Dick (2007) explain that the incorporation of ICT in the teaching and learning of mathematics, leads to the assumption that learners do not have to focus their attention on procedural work but rather place more time and emphasis on conceptual development. According to Zbiek et al. (2007) when exploring the use of ICT in mathematics it should be done by distinguishing between two mathematical activities, namely technical activities and conceptual activities. A technical mathematical activity would involve procedural work such as geometric constructions, measurements, transformations, and so forth, whilst conceptual mathematical activities would involve investigations (e.g. finding patterns), verbalisations (e.g. describing patterns found), and explanations (e.g. proving and disproving). There is however a complex relationship between technical activity and conceptual activity which makes a clear-cut differentiation between technical and conceptual activity difficult (Zbiek et al., 2007).

2.4.3 Benefits linked to conceptual mathematics

Benefits linked to the conceptual mathematical activities relate to the using of ICT for visualisation of mathematics concepts (Lu, 2008). Mathematical software such as GeoGebra, Desmos and graphing calculators especially offer visual and dynamic depictions of representations, thus making visible connections between symbols, variables and graphs. Sanders (1998) concludes that the appropriate use of dynamic geometry software can enhance mathematics teaching and conceptual development and enrich visualisation. Software that is available for the teaching and learning of mathematics include:

- Computer Algebra Systems (CAS) such as Mathematica, Maple, Derive or MuPAD;
- Dynamic Geometry Software (DGS) such as GeoGebra, Desmos, Cabri, Cinderella or Geometer's Sketchpad and AutoGraph.

According to Bottino (2004) when ICTs are implemented in mathematics teaching and learning environments, consideration should be on its effectiveness. This means looking at how educators and learners will be using the ICT resources, the effect the ICTs resources will have in the mathematics teaching and learning environment, appropriate type of ICT resources that will support the teaching and learning environment and good pedagogical practice with the ICT resources.

2.5 FACTORS THAT INFLUENCE THE INTEGRATION OF ICT INTO EDUCATION

According to Lim, Zhao, Tondeur, Chai and Chin-Chung (2013) "much of the investments made for integration of technology in education is centred around the fact that technology-mediated learning environments provide learners with opportunities to search, explore and analyse information, to solve meaningful problems, communicate and collaborate on results, hence equipping them with a set of competencies to be competitive in the 21st century marketplace". However, several studies have focused on the barriers or challenges to successful integration of ICT into educational institutions such as schools (Bingimlas, 2009; Grainger & Tolhurst, 2005; Tondeur, Van Keer, van Braak & Valcke, 2008).

Jones (2004) for instance identified numerous barriers for the integration of ICT into an educational setting. These barriers as listed by Jones (2004) include: "1) an absence of self-confidence by teachers during the integration stage, 2) insufficient access to the necessary resources, 3) not enough time, 4) the absence of professional development for teachers, 5) facing technical difficulties while using software, 6) lack of personal access during lesson preparation and 7) the educator's age". These findings also emerged in a study by Snoeyink and Ertmer (2001) who identified similar barriers including: "a lack of access to computers, lack of time, lack of quality and sufficient software, technical issues, teacher beliefs and attitudes, poor funding, lack of teacher confidence, poor support for teachers, resistance to change, lacking the necessary computer skills, poor fit with curriculum, poor training opportunities, and lack of vision as to how to integrate ICT in instruction".

Hew and Brush (2007) analysed 48 empirical studies of which 43 were peer reviewed to identify barriers to the integration of ICT for teaching and learning. The authors applied the “snowball” method and describe the criteria for selecting and excluding certain studies. Hew and Brush (2007) found 123 barriers in total for integrating ICT for teaching and learning, which they grouped into six categories, namely: 1) resources, 2) knowledge and skills of teachers, 3) institutional, 4) attitudes and beliefs of teachers, 5) assessment and 6) subject culture. The first four barriers to incorporating ICT for teaching and learning are the most pronounced - reported in 40%, 23%, 14% and 13% of the analysed studies respectively - and thought to have a direct influence on the integration of ICT for teaching and learning. The relationships between these barriers are represented in Figure 2.2. These six main categories of barriers for integrating ICT for teaching and learning will be discussed briefly.

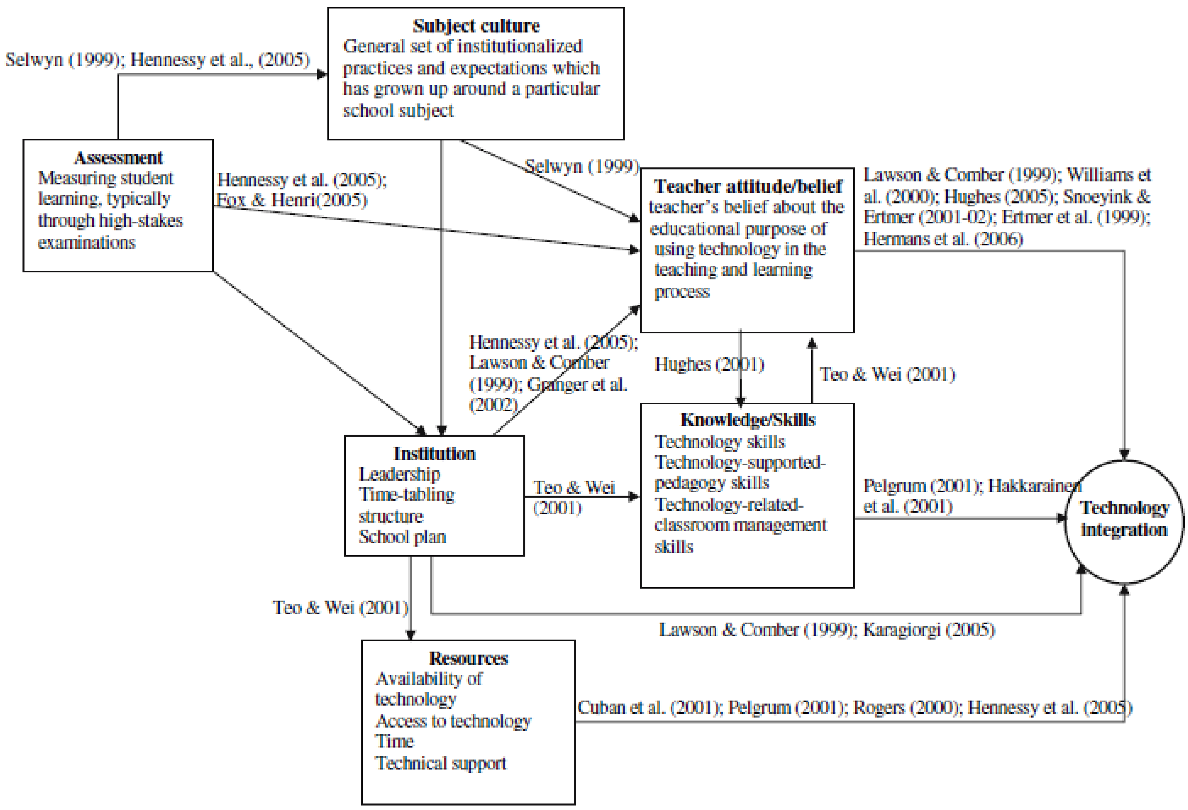

Figure 2.2: The relationships between different barriers to integrating ICT for teaching and learning (Hew and Brush, 2007, p. 231)

2.5.1 Resources

Resources include the availability of ICT, i.e. computer hardware and software, time and technical support (Hew and Brush, 2007). If resources are inadequate, teachers refrain from incorporating ICT into their classroom practice. In Tondeur et al.'s (2008) study, questions were posed to principals about the barriers they perceived with regard to integration of ICT into their schools. The following aspects were noted by principals as barriers: 1) inadequate access to resources; 2) a time management problem for implementation; 3) lack of functional ICT policy and 4) limited ICT skills of teachers.

These barriers are similar to that of Thang, Murugaiah, Lee, Azman, Than and Lee (2010), who also found that a lack of resources and especially a lack of time were factors that influenced the adoption of ICT. Participants in the study indicated that they had such a great workload having to deal with teaching subject matter, doing their administrative work and being involved in extra-mural activities, that there was thus limited time for ICT integration. Hew and Brush (2007) point out that a lot of additional preparation time is needed when teachers prepare their lessons with the aim of incorporating ICT. Technical support is another key factor for ICT integration (Hew and Brush, 2007; Inan & Lowther, 2010). According to Inan and Lowther (2010) there need to be readily available on-site support for teachers if they are to integrate ICT in their classrooms.

2.5.2 Knowledge and skills of teachers

Hew and Brush (2007) found that knowledge and skills of teachers were the second greatest factor that impeded technology integration. In their research Sivin-Kachala and Bialo (2000) scrutinised more than 300 studies and found that knowledge and skills of teachers were the greatest influential factor for successful computer integration in the classroom. A study by Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur and Sendurur (2012) also indicated two obstacles mostly preventing teachers from the use of technology in their classrooms were their existing attitudes and beliefs and their present levels of skills and knowledge available. It is imperative to note that even if resources are available, skilled teachers are needed to utilise it.

According to Laborde (2001) many teachers find the implementation of ICT into a mathematics lesson stressful because they have never been taught themselves on how to make use of ICT as part of their mathematical teaching and learning. Hargreaves (1994) points out that this lack of technical skills leads to competence anxiety and hinders the integration of ICT. Stols et al. (2015) in their study with South African mathematics teachers similarly found that 73% of the participating teachers admitted that they felt overwhelmed by the idea of integrating ICT into their teaching practices.

Hew and Brush (2007) furthermore suggest that an ICT-supported-pedagogy is necessary if teachers are to incorporate ICT into their teaching and learning. An ICT-supported-pedagogy can be categorised into three categories as follows:

1) **Replacement**: using ICT to display a poem with a data projector instead of poster on the wall, thereby keeping the lesson goal the same but by an alternative way.
2) **Amplification**: utilising ICT in order to carry out a task more proficiently without changing the task, for example learners editing each other's narratives by making use of word processors instead of doing it by hand.
3) **Transformation**: for example, learners using databases and graphing software to do investigative data analysis.

Teachers who are not proficient with or competent in using ICT, will most likely not integrate ICT in their lessons. The lack of proficiency largely stems from a lack of training to incorporate ICT in classrooms (Hennessy, Harrison & Wamakote, 2010; Osika, Johnson & Butea, 2009). Investing in computer-based ICT alone will be a waste of money if teachers do not utilise it (Inan et al., 2010).

2.5.3 Institutional Barriers to the Integration of ICT

Apart from resources and teacher's knowledge and skills, institutional barriers may also cause a lack of ICT integration. Hew and Brush (2007) provide three examples of institutional barriers:

1) **Leadership**: this could be for instance if a school principal is not aware of ICT's importance. Numerous studies for instance Sang, Valcke, Van Braak and Tondeur (2009); Otto and Albion (2003); Tondeur, Van Keer, van Braak and Valcke (2008) revealed that there is a strong relationship between the attitudes of leadership towards ICT implementation and the actual extent to which they promote and implement ICT practices in their schools.
2) **School timetables**: when incorporating ICT into the classroom environment it can be time consuming and adequate time, such as double periods for teaching and learning, needs to be allocated.
3) **School planning**: if the school administration does not plan ahead regarding how ICT will be utilised, it will not be used appropriately and therefore technological integration into lessons will be at a minimum level or not at all.

Staff development, ease of access to ICT, policies and procedures and ICT support are all aspects that form part of institutional support and are indispensable for teachers to successfully incorporate ICT in their lessons (Osika et al., 2009).

2.5.4 Attitudes and Beliefs of Teachers

Hew and Brush (2007) describe the likes or dislikes of teachers towards the integration of ICT as their attitudes. Beliefs on the other hand, which determines attitudes and include pedagogical beliefs and beliefs regarding ICT, according to Hew and Brush (2007) are the assumption that something is true. Osika et al. (2009) state that educational beliefs are the degree to which a teacher believes that a computer attends to vital educational needs, deeming it more (or less) valuable and integrating ICT in the same measure as held by its perceived value.

Demetriadis et al. (2003) and Grainger and Tolhurst (2005) asserted that ICT practices in schools are profoundly influenced by teachers' attitudes towards the infusion of technology into schools and state that motivating teachers to use ICT remains a significant problem. Teo (2008) regards teacher's attitudes and beliefs towards the use of ICT as some of the greatest obstacles in making use of ICT when teaching. Tondeur et al. (2008) asserts that teachers with constructivist pedagogical views, which are more learner-centred, are more inclined to integrate computers in demanding ways into their teaching, while those adhering to teacher-centred approaches (traditionalists) are less prone to integrate computers in their teaching and learning.

2.5.5 Assessment

Assessment, which includes formative and summative assessment, is defined as the evaluation of learner's learning (Hew and Brush, 2007). Summative assessment commonly done at the end of a course and used to determine if a learner passes or fails her/his grade, could discourage teachers from integrating ICT. Hew and Brush (2007) emphasise that teachers could feel pressured to cover the scope of the curriculum and therefore would not want to spend additional time to try and incorporate ICT over and above the jam-packed curriculum. Researchers Donnelly, McGarr and O'Reilly (2011) supports the latter claim. In their research one of the teachers interviewed, stated that they had limited ICT skills, but their current methods of instruction reaped rewards as far as exam results were concerned which were all that parents cared about. Teachers therefore are not motivated to use ICT unless the way of assessment changed, since they (and the system) are result-driven (Donnelly et al., 2011). The time it takes teachers with limited technological skills to learn how to integrate ICT might have a negative impact on their learners' results which would discourage them from utilising ICT.

Furthermore, the integration of ICT often seems to be in contrast with how external question papers are set (Hew and Brush, 2007). Hennessy, Ruthven and Brindley (2005) describe a situation where graphical calculators are not allowed in nationwide question papers. In this situation, teachers are not motivated to integrate this particular ICT in their lessons for the fear of the disadvantage that might be brought upon their learners if they are used to work with graphical calculators in the class situation. In South African schools, graphical calculators are not allowed either, as stated in the Curriculum and Assessment Policy Statement (CAPS) of the South African education department: "None graphic and none programmable calculators are allowed... Calculators should only be used to perform standard numerical computations and to verify calculations by hand." (DBE, 2011).

2.5.6 Subject culture

Subject culture is traditionally shaped and underpinned by generations of school practice, subject content, pedagogies and assessment (Hew and Brush, 2007). This subject culture or "subjective culture" as referred to by Thompson, Higgins and Howell (1991) comprises of three elements. They are, norms (where members of a culture in given circumstances teach themselves to do what they deem correct and suitable), roles (which also concern behaviours thought to be correct but identified with people holding a specific position in a group, society or social system), and values (categories that are difficult to understand but with strong affective elements) (Thompson et al., 1991).

Ertmer and Ottenbreit-Leftwich (2010) state that each school, and even each teaching team within a school, has a set of norms that guides behaviours and instructional practices. These norms address: "everything from which values and goals are promoted, to which instructional methods are preferred, to which tools or resources are acceptable to use" Ertmer and Ottenbreit-Leftwich (2010). Given this, it's not surprising that according to Hennessy et al. (2005, p. 161) "teachers are reluctant to adopt a technology that seems incompatible with the norms of a subject culture". Somekh (2008) explains, that teachers are not 'free agents' and their usage of ICT for teaching and learning vastly depends on the intertwining cultural, social, and organisational contexts in which they live and work.

2.6 CONCEPTUAL FRAMEWORK

This study explores the integration of ICT by mathematics teachers in their classrooms by attempting to address the following three questions: 1) *what* ICTs are currently being employed by mathematics teachers; 2) *how* do the teacher apply these ICTs in their classrooms and 3) *why* do teachers employ these ICTs. In an effort to best address these three questions I propose a conceptual framework that combines the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003, p. 447) framework and the

Substitution, Augmentation, Modification and Redefinition (SAMR) (Puetendura, 2010) model. Figure 2.3 is a schematically diagram of the proposed conceptual framework.

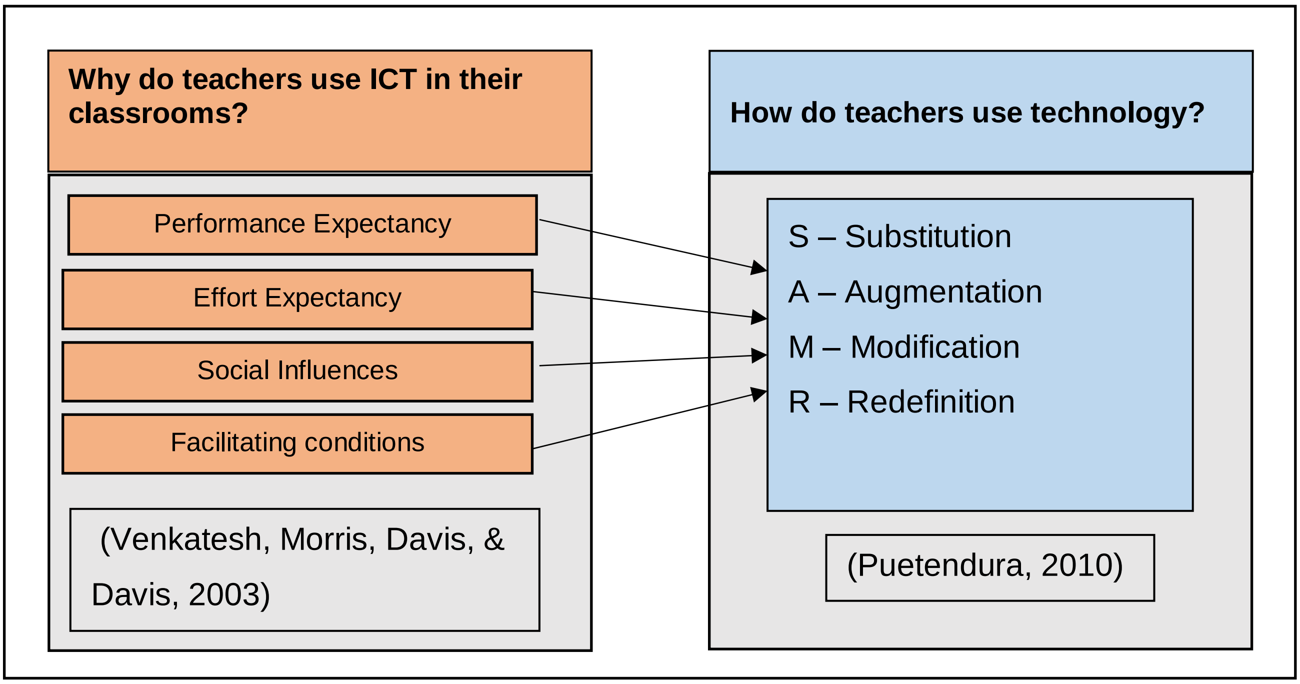

Figure 2.3: Conceptual framework for this study

2.6.1 The Unified Theory of Acceptance and Use of Technology (UTAUT) framework

In the previous section, factors that influence teacher's utilisation of ICT for the teaching and learning of mathematics were discussed. In the available literature, there are many models that aim to explain human behaviour and some are refined to explain the acceptance of ICT. A brief overview of some Technology Acceptance Models can be viewed in Table 2.2. Venkatesh et al. (2003) reviewed eight major models for explaining human behaviour and incorporated components from these models into their unified model called the Unified Theory of Acceptance and Use of Technology (UTAUT). The eight models that Venkatesh et al. (2003) evaluated are:

> The Theory of Reasoned Action, the Technology Acceptance Model, the Motivational Model, The Theory of Planned behaviour, a model combining the Technology Acceptance Model and The Theory of Planned Behaviour, the model of PC utilization, the innovation diffusion theory and the social cognitive theory. Venkatesh et al. (2003, p. 428)

To see an overview of the eight models in terms of their core constructs and definitions, refer to Table 1 in Venkatesh et al. (2003, p. 428-432) as well as a briefer summary in Table 2.2, copied from Birch (2009).

Table 2.2: Brief overview of the Technology Acceptance Models used to create UTAUT

Name of Model	Acronym / Alternate Name	Level of Analysis	Main dependent Constructs / Factors	Main independent Constructs / Factors	Originating Authors
Theory of Reasoned Action	TRA	Individual	Behavioural intention, behaviour	Attitude toward behaviour, & subjective norm	Fishbein (1967); Ajzen and Fishbein (1973); Fishbein and Ajzen (1975)
Technology Acceptance Model	TAM (adaptation of TRA)	Individual	Behavioural Intention to Use, System Usage	Perceived usefulness, perceived ease of use & subjective norm (only in TAM2)	Davis (1986); Davis (1989)
Motivational Model	MM	Individual	Behavioural intention	Extrinsic motivation & intrinsic motivation	Vallerand (1997)
Theory of Planned Behaviour/ Decomposed Theory of Planned Behaviour	TPB DTPB	Individual	Behavioural intention,	Attitude toward behaviour, subjective norm, perceived behavioural control	Ajzen (1985); Ajzen (1991)
Combined Theory of Planned Behaviour / Technology Acceptance Model	C-TAM-TPB	Individual	Behavioural usage	Attitude toward behaviour, subjective norm, perceived behavioural control & perceived usefulness	Taylor & Todd (1995)
Model of PC Utilization	MPCU	Individual	Behavioural intention	Job-fit, complexity, long-term consequences, affect toward use, social factors & Facilitating Conditions	Thompson et al. (1991)
Innovation Diffusion Theory	IDT/DOI, Diffusion of Innovations	Group, Firm, Industry, Society	Implementation Success or Technology Adoption	Relative advantage, ease of use, visibility, result demonstration ability, image & compatibility	Lazarsfeld et. al. (1949); Rogers (1962); Rogers and Shoemaker (1971); Rogers (1995)
Social Cognitive Theory	SCT	Individual/ Group	Learning, Change in behaviour	Outcome expectations-performance, outcome expectations-personal, self- efficacy, affect & anxiety	Bandura (1986)

Source: "Brief overview of the Technology Acceptance Models used to create UTAUT" copied from Birch (2009, pp. 25-26)

Venkatesh et al. (2003) applied the models referred to above on data from four organisations over a period of six months and found that these models "explained between 17 percent and 53 percent of the variance in user intentions to use Information Technology" (p. 425). They then applied their UTAUT model on the same data and the results seemed to imply that their model surpassed all eight models evaluated, with an adjusted R^2 value of 69%. Data from two other organisations further confirmed their model to be valid with an adjusted R^2 of 70% (Venkatesh et al., p. 425).

The UTAUT model was selected as part of the conceptual framework for this study since it performed considerably better than other models for explaining human behaviour. The four main constructs of the UTAUT model, namely Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC) are viewed by Venkatesh et al. (2003) to directly influence whether people accept and use ICT. The UTAUT model explains the use of ICT in general, but links up with the six categories of barriers for the integration of ICT as identified by Hew et al. (2007). For a detailed discussion on the six barriers see Section 2.5 above. Comparing Venkatesh et al.'s (2003) UTAUT model to Hew et al.'s (2007) six categories, Performance Expectancy could be linked to assessment; Social Influence could be linked to subject culture and Facilitating Conditions could be linked to resources, knowledge/skills and institutional barriers. Venkatesh et al.'s (2003) Effort Expectancy construct is similar to Hew and Brush's (2007) teacher attitudes/beliefs barriers.

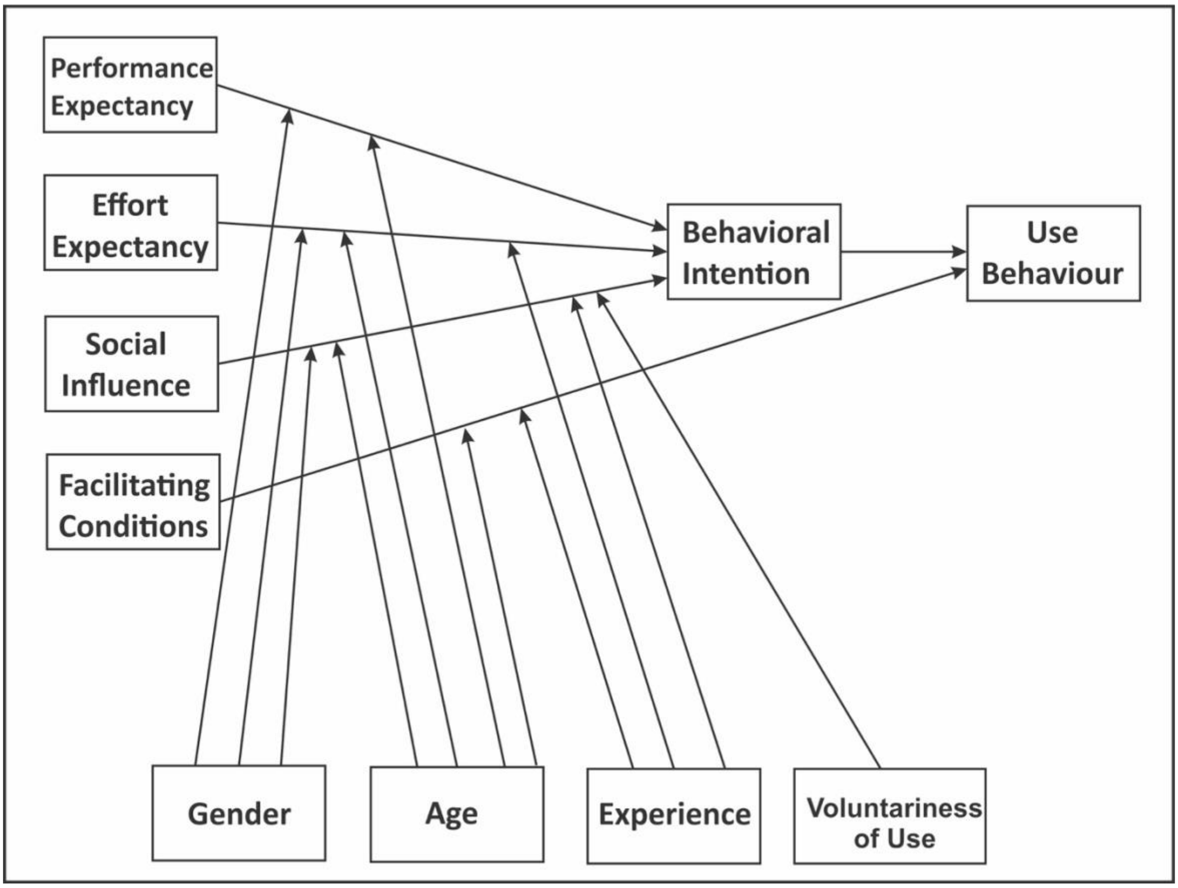

Figure 2.4: Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003, p. 447)

In their model, Venkatesh et al. (2003) hold the view that four constructs – i.e. Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions – have a direct influence on whether people accept and use ICT. They furthermore found that attitudes toward using ICT, computer self-efficacy and computer anxiety do not directly influence people's intention to use ICT. Each of the four components, namely PE, EE, SI and FC, of Venkatesh et al.'s (2003) UTAUT model depicted in Figure 2.4 will be discussed in more detail in the following sections. In later discussion, the reader should also note that an amended version of the UTAUT model is used in this study. This is not uncommon, as amended versions are often proposed and utilised; see, for example, (Tosuntaş, Karadağ, & Orhan, 2015).

2.6.1.1 Performance Expectancy

Venkatesh et al. (2003) define Performance Expectancy (PE) as the degree to which an individual believes that using ICT will assist him/her in enhancing their job performance. In this study, PE therefore, is defined as the degree to which mathematics teachers consider that utilising ICT in the classroom will enhance the teaching and learning environment. This might influence their intention to use ICT in their classrooms.

Venkatesh et al. (2003, p. 447) used five constructs from the various models mentioned in Table 2.2, that are relevant to PE, namely: “perceived usefulness (TAM/TAM2 and C-TAM-TPB), extrinsic motivation (MM), job-fit (MPCU), relative advantage (IDT), and outcome expectations (SCT)”. According to Davis (1989) and Davis, Bagozzi and Warshaw (1989) perceived usefulness refers to the extent that a person believes that the usage of a specific system would advance their work experience with a positive use-performance correlation when using the system. Extrinsic motivation is defined by Venkatesh and Speier (1999) as the intentions behind a certain behaviour (such as using ICT in the classroom) because it is believed that it would aid the user to benefit from this behaviour. Job-fit determines the degree of a person’s belief that the utilisation of ICT would boost their job performance by aiding in decision making or assisting with shortening the time needed to complete key tasks (Thompson et al.,1991), which is similar to perceived usefulness.

The degree to which a new idea (or innovation) is seen to be an improvement for its predecessor is described as the relative advantage by Moore and Benbasat (1991). Outcome expectations on the other hand relates to positive behaviour. According to Compeau and Higgins (1995) and Venkatesh et al. (2003), a person would rather assume behaviour with positive outcomes than assume behaviour that they do not see as useful in enhancing their performance. The performance expectancy construct was found by Venkatesh et al. (2003) to be the leading predictor of intention to use ICT. They furthermore found that gender and age are determining factors on the influence of people’s Performance Expectancy on their Behavioural Intention which is especially true for younger men.

2.6.1.2 Effort Expectancy

Effort Expectancy (EE) is an individual's apparent ease of use of ICT (Venkatesh et al., 2003). In this study, the effort expectancy is a mathematics teacher's perceived effortless use of ICT for the teaching and learning of mathematics in the classroom which might influence his/her intention to use ICT.

The three constructs used in EE from Table 2.2 include: "perceived ease of use (TAM/TAM2), complexity (MPCU), and ease of use (IDT)" (Venkatesh et al., 2003, p. 450). Perceived ease of use according to Davis (1989) and Davis, Bagozzi and Warshaw (1989) is the extent to which someone's beliefs that utilising a specific system would be effortless. Venkatesh and Davis (2000) proposed TAM2 as an extension of the Technology Acceptance Model (TAM) and retained perceived ease of use for directly influencing perceived usefulness, since systems that use less effort will increase performance. Contrasting to ease of use, Rogers and Schoemaker (as cited in Thompson et al., 1991, p. 128), define complexity as "the degree to which an innovation is perceived as relatively difficult to understand and use". Thompson et al. (1991)'s complexity construct is opposite to Davis' (1989) ease of use construct, their hypothesis measures a negative correlation instead of a positive relationship like Davis. This suggests that when ICT is perceived too challenging, people will not adopt it.

Similar to perceived ease of use and contrasting to complexity, Moore and Benbasat, (1991, p. 215) define ease of use as "the degree to which the Personal Work Station (PWS) is easy to learn and use" and all ten of their initial fourteen items that they reserved for scaling the "ease of use" construct was obtained from Davis' scale for "perceived ease of use". According to Venkatesh et al. (2003) there are meaningful relationships between the Effort Expectancy constructs in both planned and obligatory situations. However, Effort Expectancy declines significantly with extensive and sustained use of ICT. Effort Expectancy was also found to be more prominent for older women who are not familiar with the use of certain ICT, with age, gender and experience playing a role in Effort Expectancy's influence on Behavioural Intention.

2.6.1.3 Social influences

Social Influence (SI) is an individual's opinion of what significant people around them think of their application of ICT (Venkatesh et al., 2003). Social Influence in this study is a mathematics teacher's opinion on what other significant people (namely their principal, subject-head and colleagues), perceive his\her use of ICT to be. This might influence his/her intention to use ICT.

The three constructs that make up SI is "subjective norm" (TRA, TAM2, TPB/DTPB, and C-TAM-TPB), social factors (MPCU), and image (IDT)" (Venkatesh, 2003, p. 451). Fishbein and Ajzen (1975) defined subjective norm as "the person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Venkatesh et al., 2003, p. 428). Taylor and Todd (1995) denote subjective norm as Social Influence. Social factors refer to what people think they ought to do (Thompson et al., 1991). Triandis (1977) extended the term social norms, and named it social factors which are "the individual's internalization of the reference groups' subjective culture, and specific interpersonal agreements that the individual has made with others, in specific social situations" (Thompson et al., 1991, p. 126). Subjective culture is discussed earlier in the chapter (refer to Section 2.5.6).

Image, also referred to as social approval, is defined as the degree to which the utilisation of modern technology is seen to boost an individual's status in his/her social circle (Moore & Benbasat, 1991). Social Influence according to Venkatesh et al. (2003) is unrelated in the intentional use of ICT but noteworthy when the usage of ICT is obligatory. This, however, is also becoming irrelevant eventually with continued use of ICT. Social Influence was more prominent for older women who are not familiar with the use of certain types of ICT, with age, gender, experience and obligatory use playing a significant role in social norm's influence on Behavioural Intention (Venkatesh et al., 2003).

2.6.1.4 Facilitating conditions

Facilitating Conditions (FC) are defined as the level of an individual's perception that administrative and technical infrastructure exist to support the use of ICT

(Venkatesh et al., 2003). Facilitating Conditions in this study refer to the level of which a mathematics teacher perceives that skills, knowledge, resources and support regarding the use of ICT exist to support the use of ICT for the teaching and learning of mathematics. This might influence his/her actual use of ICT for teaching and learning.

The three constructs from Table 2.2 that Facilitating Conditions represents include: “perceived behavioural control (TPB/ DTPB, C-TAM-TPB), Facilitating Conditions (MPCU), and compatibility (IDT)”, with these constructs prepared in a way that will eliminate obstacles when using ICT (Venkatesh et al., 2003, p. 453). Perceived behavioural control is the perceived ease or difficulty linked with carrying out a certain behaviour (Ajzen, 1991). Perceived behavioural control is one of the constructs that directly influences Behavioural Intention, which consecutively influence behaviour (Taylor & Todd, 1995).

Facilitating Conditions in the MPCU model refer to unbiased factors in a setting that observers agree on to make an act easy to do (Thompson et al., 1991). In an ICT context, the support available to a user is an example that can affect ICT use. The degree to which new ICTs is seen to comply with a prospective user’s established values, needs and experiences is referred to as compatibility (Moore & Benbasat, 1991). Venkatesh et al. (2003) found that Facilitating Conditions will not have a considerable influence on Behavioural Intention in the UTAUT model, since this result is taken into consideration by Effort Expectancy. Facilitating Conditions is significant in forecasting behaviour in the TPB/DTPB though, because Effort Expectancy does not form a part in the latter models (Venkatesh et al., 2003). Facilitating Conditions are also emphasised by age and experience, such that there is a stronger relationship between the use of ICT and Facilitating Conditions for older, experienced people (Venkatesh et al., 2003).

2.6.1.5 Behavioural Intention

The first three constructs (PE, EE and SI) of the UTAUT model are theorised to influence Behavioural Intention (Venkatesh et al., 2003). Behavioural Intention is referred to in this study, as the mathematics teachers’ intention to use ICT for teaching and learning. In the questionnaire, teachers’ intention to use ICT in the next six months since completing the questionnaire was measured. Just as facilitation conditions are predicted to influence (actual) “use behaviour”, Behavioural Intention is also anticipated by Venkatesh et al. (2003) to forecast (actual) “use behaviour”, consistent with other intention models they have discussed. The (actual) “use behaviour” is defined in this study as the mathematics teacher’s actual use of ICT for teaching and learning. As such this study predicts that mathematics teachers’ intention to use ICT for teaching and learning will determine their actual use of ICT for teaching and learning.

2.6.1.6 Moderator Effects

According to Venkatesh et al. (2003) gender, age, experience, and voluntariness of use moderate the effect of the four direct determinants (PE, EE, SI and FC) on Behavioural Intention and actual use (see Figure 2.4). In summary Venkatesh et al. (2003) hypothesised the following for each construct:

- Gender and age moderate the influence of Performance Expectancy on behavioural intention. This was particularly for younger men.
- Gender, age and experience moderate the influence of Effort Expectancy on Behavioural Intension, particularly for younger women with little experience.
- Gender, age, voluntariness and experience moderate the influence of Social Influence on behavioural intention, specifically for older women in a compulsory environment with little experience.
- Age and experience moderate the influence of Facilitating Conditions on actual use, especially for older users with greater levels of experience.

In this study, the conceptual framework used for the acceptance and use of ICT was based on UTAUT. However, since the study focused on specifically what ICTs are being integrated by mathematics teachers, it was believed that all teachers use some form of ICT. Therefore, ICT use in schools was not viewed as voluntary but as an obligation and experience and voluntariness of use moderators were excluded from the model. Furthermore, the aim of this study was not to see, for example, whether females made more (or less) use of ICTs in the classroom than males or whether younger participants made more (or less) use of ICTs in the classroom than older participants and, therefore, the use of gender and age were also excluded as moderators. Although the moderators were not the focus of this study and were, therefore, excluded from the UTAUT model, all other components and hypotheses were created according to the UTAUT structure (see Figure 2.4).

2.6.2 The Substitution, Augmentation, Modification and Redefinition (SAMR) integration framework

The integration or utilisation of ICTs in the classroom can be implemented in a vast majority of different ways, utilising tools such as: computers, laptops, software, CDs/DVDs, Web 2.0 technologies, Internet, mobile phones, video conferencing etc. Within mathematics classrooms the process of integrating ICT is done differently, as it depends not only on the available tools but also the knowledge of ICT that the teacher possesses. The Substitution, Augmentation, Modification and Redefinition (SAMR) model classifies ICT usage in four categories namely Substitute, Augmentation, Modification and Redefinition (see Figure 2.5 below). The SAMR model is a four-level approach for selecting, using, and evaluating technology use in a classroom setting (Puentedura, 2006).

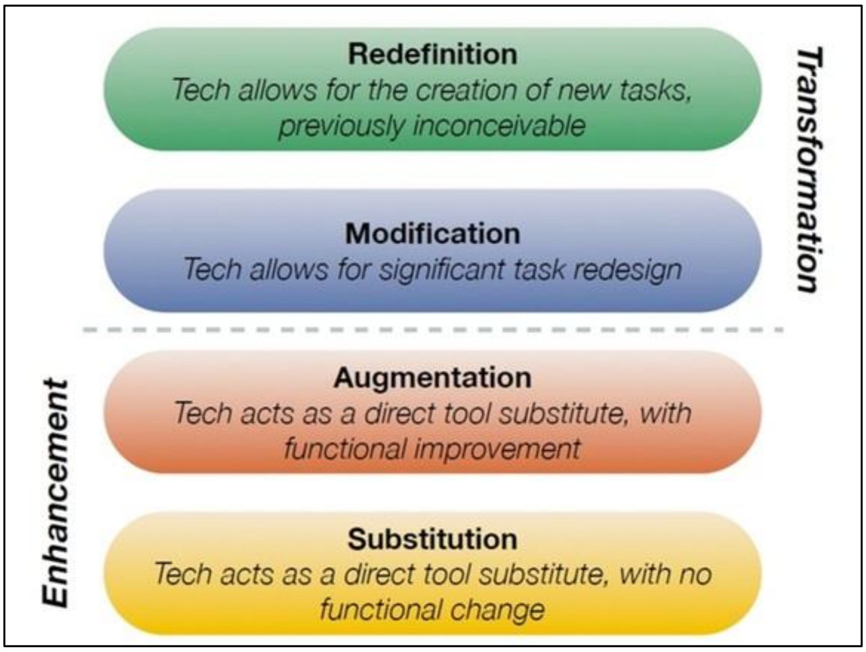

Figure 2.5: Puetendura (2010). A Brief Introduction to TPCK and SAMR.

2.6.2.1 Substitution

According to Puentedura (2014) in the substitution category, digital technology is substituted for analog technology, but the substitution produces “no functional change”. Technology therefore acts as a direct tool, a substitute, with no functional change in the teaching and learning practices (Nkonki & Ntlabathi, 2016). In a learning environment, technology is used to do the same things the teachers did without it. According to Lubega, Mugisha and Muyinda (2014) in the substitution category a computer is merely used to replace a typewriter to produce documents but with no substantial change to their function. Lund (2015) provides three examples of substitution: 1) If you have learners using word processing software and a printer to hand in a hard copy of an assignment, then they have performed a substitution; 2) Substituting a highlighter and sticky notes with the built in capabilities of an e-book, where it allows you to mark up your book and insert comments, is also a form of substitution 3) Uploading your curriculum as a Portable document format (Pdf) or Word document on to a learning management system, instead of printing individual copies, would also refer to substitution.

2.6.2.2 Augmentation

In the augmentation category Puentedura (2014) explains that digital technology is substituted for analog technology and the substitution produces “some functional improvements”. According to Fabian and MacLean (2014) in the teachig and learning environment, the same things are done with technology but there are however, minor improvements. Therefore, technology acts as a direct tool, a substitute with functional improvements in teaching and learning practices. Building on the example of Lubega, Mugisha and Muyinda (2014) under the augmentation category, a computer can for example be used to replace a typewriter but with substantial increase in functionality such as cut and paste or spell checking etc.

Lund (2015) explains that if learners are asked to submit a typed-up assignment electronically then they are completing this at the augmentation level because, the online version allows for some functional enhancements, such as online mark-up and grading. Furthermore, Lund (2015) also suggests that quizzes taken online would normally fall into the augmentation category. The capability of completing a quiz that can have randomised questions and be automatically graded, with aggregated statistical data instantaneously available are marked enhancements over the traditional way of manually compiling statistics (Lund, 2015). According to the SAMR model the two categories mentioned above enhances the teaching and learning process. In the two categories that follow below the dotted line ICTs are used to transform i.e. modify or redefine the teaching and learning processes.

Lund (2015) notes that the dotted line in the middle symbolises a tough boundary to cross. The boundary illustrates a movement from enriching traditional classroom activities into a territory where the activities done in a classroom are reliant upon technology and the educational experience is transformed by the activity itself. The task changes from being the medium through which learning can be attained, to an educational experience.

2.6.2.3 Modification

Under the modification category ICT allows for significant task redesign (Puentedura, 2014). According to Lund (2015) in the modification category technology allows the very nature of the task to change considerably, and to be redesigned to fit a potentially different, deeper outcome. Using the writing example from above, the teacher can integrate Web 2.0 tools such as blogs and wikis, into a lesson (Lund, 2015). This according to Lund (2015) transforms a writing activity from something learners would normally complete in isolation to a richer collaborative exercise wherein learners can critique one another before the final submission. According to Lund (2015) it places the responsibility on the learner to perfect their own techniques and means that the fundamental writing questions will often be more learner-directed. This is emphasised by Kihoza, Zlotnikova, Bada and Kalegele (2016) who state that under the modification category there is an emphasis on shared knowledge created using textual, visual, and audio tools.

Lubega et al. (2014) further explains that integrating pedagogy and assessment with email, Computer Algebra Systems (CAS) and graphing packages such as GeoGebra also form part of the modification category. According to Hamilton, Rosenberg and Akcaoglu (2016) an example would be if a teacher in a secondary science class, modifies how learners are taught of the concept of light, from showing the traditional diagram of light travelling to a more interactive computer simulation of light learners can change, this would also form part of modification as the learning is student directed.

2.6.2.4 Redefinition

With redefinition, technology allows for the creation of new tasks which were previously inconceivable, a remix and redesign process, a total transformation of one's practice (Fabian & MacLean, 2014). According to Kihoza et al. (2016) redefinition level is achieved when technology is used to create novel tasks. Referring to the writing example used in the previous 3 levels, Lund (2015) explains that at the redefinition level, the teacher can ask learners to create a multimedia audio or video project of the written assignment, using computer technology that is widely available these days. This task would have been previously inconceivable without technology. Redefinition is the highest level of the SAMR model, is the most difficult to attain and focuses on visualisation of narrative and structural aspects of text (Jude, Kajura & Birevu, 2014; Lund, 2015; Myers, 2014; Puentedura, 2012).

2.6.2.5 Utilising the SAMR model in this study

Researchers and educators have over the last decade developed standards, frameworks, models and theories to serve as a guide for the integration of ICT into the educational domain (Hamilton et al., 2016). The TIM framework discussed under Section 2.3.2.1 and the SAMR model discussed here are only two such examples. It is imperative to point out that the integration of ICT into the education domain is of a complex nature. As Mishra and Koehler (2006) suggest: "We are sensitive to the fact that in a complex, multifaceted, and ill-structured domain such as integration of technology in education, no single framework tells the 'complete story'; no single framework can provide all the answers." The four steps of the SAMR model however, provides a tool for assessing and evaluating how ICT practices impact a traditional classroom setting (Hos-McGrane, 2014; Lund, 2015; Myers, 2014; Puentedura, 2012; Tucker, 2013). Taking this into consideration as well as the type of data that would be generated from the questionaire, the reseacher therefore chose to make use of the SAMR model in this study. Although the SAMR model has been used to study ICT use in many fields such as higher education and biology education (Romrell, Kidder & Wood, 2014), it is not currently represented in the existing literature (Hamilton et al., 2016). Furthermore, Marcovitz and Janiszewski (2016) suggest a limitation of the model is its focus on technology rather than learning. However, this study has a focus on the use of ICT so the SAMR model can thus be utilised in this study to answer the research question: How are teachers utilising ICT in their classrooms for teaching and learning.

2.7 CHAPTER SUMMARY

The integration of ICT in education has undoubtedly affected teaching, learning and research within this domain (Drent & Meelissen, 2008; Yusuf, 2005). Research has shown that technology can be applied effectively as a tool for the teaching and learning environment (Bransford et al., 2000; Bruce & Levin, 2003), but also cautions that the integration of technology can be a complex and challenging process (Wilson-Strydom, Thomson & Hodgekinson-Williams, 2005). Leonard and Leonard (2006) point out that problems, in fully integrating technology into the school curriculum, still occur in many schools. Numerous barriers for the integration of ICT for teaching and learning exist in the discourse, but Hew and Brush (2007) identified six main categories namely, resources, knowledge and skills of teachers, institutional, attitudes and beliefs of teachers, assessment and subject culture.

Limited resources, including lack of technical support, or even limited access to existing resources within a school environment, hampers teachers' use of ICT for teaching and learning. Even if resources are available, teachers need to be skilled and knowledgeable to utilise ICT to its fullest potential for teaching and learning. Institutional barriers for integrating ICT include leadership, e.g. a school principal who is not in favour of utilising ICT for teaching and learning, the school time-table that does not provide adequate time (such as double periods) to integrate ICT for teaching and learning, school planning by the administration on how ICT should be incorporated in lessons (Hew and Brush, 2007) and even fixed school curriculums with too much content to be covered, leaving teachers practically no time to incorporate ICT for teaching and learning (Hennessy et al., 2010). Teachers' attitudes and beliefs lead teachers who are more learner-centred to be more inclined to integrate ICT for teaching and learning, while those adhering to teacher-centred approaches are less likely to integrate ICT in their teaching and learning (Tondeur et al., 2008).

Assessment seems to influence the integration of ICT for teaching and learning since external examination, for instance, might not allow the use of computers and applicable software to solve mathematical problems, therefore discouraging teachers' use of ICT for fear of putting their learners at a disadvantage. Subject culture is a barrier to the utilisation of ICT if it is seen as an intrusion to ways things have always been done, i.e. teaching without the use of ICT. Internal factors such as competence, personal beliefs and anxiety as well as external factors such as demographics – specifically age and gender, class size, and institutional support also influence the integration of ICT for teaching and learning purposes (Osika et al., 2009).

Venkatesh et al. (2003) developed the UTAUT model that performed significantly better than eight other models for measuring ICT integration. This model found that Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions have a direct influence on the integration of ICT and it has not been applied in many South African studies. There is a huge gap in the literature for applying the UTAUT model to explain South African mathematics teachers' integration of ICT for teaching and learning.

3. CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, the researcher's own perspective of critical realism as paradigmatic perspective is discussed. Following this discussion, the research design and methods are described. Subsequently, sampling, data collection strategies, and data analysis for this study are discussed. Finally, validity and reliability concerns, as well as ethical issues are addressed.

3.2 PARADIGMATIC PERSPECTIVES

To arrive at a framework for this study I reviewed different paradigms from the methodology literature. Lincoln (2010) emphasises the importance of paradigms as it gives insight into the researcher's perspective. According to Draper (2011), a researcher's inquisition paradigm shapes his\her research design with researchers convoying their own set of beliefs through their work.

A review of the research methodology literature suggests that three main paradigms exist, namely: 1) positivism (empiricism) or post-positivism; 2) interpretivism or hermeneutics and 3) critical theory (Cohen, Manion & Morrison, 2007, 2011; Denzin & Lincoln, 2005; Usher, 1996). However, further reviews suggest that other thinking related to paradigms do exist. Guba and Lincoln (2005) refer to positivism, post-positivism, constructivism, critical theory and participatory paradigms. According to Denzin and Lincoln (2005) the paradigms can be grouped into three main categories namely: 1) positivism and post-positivism; 2) constructivism and 3) critical theory and participatory paradigms. Healy and Perry (2000) acknowledge the first three, but add a fourth paradigm, namely, realism. Creswell (2003) and Creswell and Plano Clark (2007) also consider the traditional three paradigms, namely: 1) post-positivism (they exclude positivism); 2) constructivism and 3) advocacy and participatory paradigms, but they also define a fourth one namely 4) pragmatism.

The aim of this research is to gain a deeper insight into what, how and why ICTs are being integrated by mathematics teachers. Guided by this aim, I have elected to follow a post-positivist paradigm. The assumption of post-positive research is that scientific and common-sense reasoning are in essence the same thing (Trochim, 2006b). A post-positivist suggests that a reality does exist, but that we can know reality only imperfectly due to our own human limitations, including subjectivity (Mertens, 2014). Therefore, post-positivists researchers acknowledge that individuals are not able to be held to the rigorous measurements of the positivistic approach (Mertens, 2014; Trochim, 2006b). Furthermore, Mertens (2014) and Trochim (2006b) also assert that the post-positivist accepts that the information stated by the individual is significant and cannot necessarily be generalised to others. A post-positivist researcher also accepts that he/she cannot be completely objective at all times (Denzin & Lincoln, 2005; Guba & Lincoln, 2005) and endeavours to limit his\her subjectivity present in their work (Trochim, 2006b). This subjectivity part of post-positivism is in contrast with the positivist position.

A relatively new form of post-positivism is critical realism (Brandt, 2006). According to Bhaskar's (1998) critical realist theory there exists a greater reality, free of our beliefs or ideas. A critical realist believes that there is a reality independent of their thinking about it, which can be studied by a scientific approach. Bhaskar (as cited in Houston, 2001, p. 850) differentiates between three levels of reality, namely: "the empirical level consisting of experienced events; the actual level comprising all events whether experienced or not; and the causal level embracing the 'mechanisms' which generate events". Easton (2010, p. 128) explains that critical reality distinguishes between the "real world, the actual events that are created by the real world and the empirical events that can be captured and recorded". The researcher decided on critical realism as the lenses through which to conduct this research because it contains fundamentals of both positivism and constructivism (Krauss, 2005). According to Krauss (2005) critical realism is both aware of the nature of things (positivism), as well as the human agency or factor (constructivism) and thus strives to learn about observable as well as non-observable constructs, free of events produced by them.

Both qualitative and quantitative research approaches are suitable in a post-positivist, critical realism paradigm (Denzin & Lincoln, 2005; Guba & Lincoln, 2005;

Krauss, 2005). However, according to Mertens' (2014) from a methodological stance, the post-positivist researcher focuses primarily on quantitative data. A critical realism paradigm therefore allows for the researcher to make use of either a quantitative or a qualitative approach or both (mixed method), whichever approach with their appropriate methods will answer the research question. Utilising a post-positivistic critical realist paradigm, the researcher aims to bridge the gap between the sciences and the social sciences and realising that the results are fallible and not necessarily generalisable.

3.3 RESEARCH METHODS

The sampling and participants in the study, data collection strategies and instruments, as well as data analysis procedures will be discussed in the following sections.

3.3.1 Sample and Participant Profile

To obtain as large a response as possible, the use of both a hard copy questionnaire as well as an online survey were utilised. Hard copies were distributed at professional development sessions that teachers attended, whilst the link to the e-survey was sent electronically to teachers (see Annexure C). In total 191 teachers completed the questionnaires (either online via the e-survey or a hard copy of the same questionnaire). From Table 3.1 it can be seen that the largest group of the teachers was the one where teachers were between 50 and 59 years old (29.32%) and the majority of teachers were younger than 59 years of age (94.24%). Only 21% of the respondents were male and the rest (79%) were female (refer to Table 3.2). Furthermore, to provide some elucidation on the background of the respondents, the e-survey was available in both English and Afrikaans. However, the majority of respondents (84.81%) completed the Afrikaans e-survey whilst only 15.19% completed the English version. See Section 4.2 for further elaboration on the demographics of the respondents.

Table 3.1: Participating teacher's age

Age range	Frequency	Percentage %
20 - 29	40	20.94
30 - 39	46	24.08
40 - 49	38	19.90
50 - 59	56	29.32
60 - 69	8	4.19
> 69	3	1.57
Total	191	

Table 3.2: Participating teacher's gender

Gender	Frequency	Percentage %
Female	151	79
Male	40	21
Total	191	

3.3.2 Data Collection Strategies and Instruments

A structured questionnaire, in the form of a survey, was used to gather data in this study. The questionnaire was administered in two ways, a paper-based survey and an e-survey (Google Forms) questionnaire. The questionnaire had a high degree of structure with mainly close-ended questions. The high-level structuring led to a high predictability of data collected and data could therefore be pre-coded or classified into categories before data collection (Plowright, 2011). Both the survey and e-survey questionnaires were translated into Afrikaans before data collection commenced - since the population under investigation was mostly Afrikaans teachers.

The paper-based questionnaires were distributed at professional development sessions conducted by the researcher and it was received back immediately after completion in order to have a better return rate for the questionnaires. As web-based questionnaires are more frequently used in social and educational research (Cohen et al., 2011; Plowright, 2011) the researcher additionally invited teachers electronically via e-mail and short message service (SMS) to participate in the study by including a link to the Google Forms where the questionnaire was hosted (Cohen et al. 2011). The rationale behind an electronic survey additional to the hard copy version of the same questionnaire was to obtain a higher response rate for the study.

The closed-ended questions of the questionnaire were based on Venkatesh et al.'s (2003, p. 460) items regarding the use of ICT in general, but it was adapted by specifically focusing questions on the use of ICT within the educational environment and also adding additional questions to gain better insight into mathematics teachers' use of ICT for teaching school mathematics topics. For the open-ended questions the SAMR model was utilised (Puentedura, 2014). The breakdown of the questionnaire was as follows:

Section A: Demographical information of teachers.

Section B: Which ICTs are used by the participating teacher for teaching mathematics?

Section C: Reasons for applying the use of ICT in teaching and learning of mathematics (measuring UTAUT constructs).

Section D: Application of ICT during a mathematics lesson (measuring SAMR constructs).

Section E: Actual and intentional use of ICT.

3.4 DATA ANALYSES

This study conducted both descriptive and inferential statistics to provide different insights into the nature of the data gathered. According to Creswell (2009) engaging with one type of statistical analysis alone cannot give the complete picture. Park, Nam and Cha (2012) explain that descriptive statistics are statistical analyses that describe the gathered data. They are straightforward analyses which do not implicitly generalise beyond the collected data (Park et al., 2012). The descriptive statistics used in this research were aimed to describe the basic features of the data and render simple summaries of the sample and the measures (Bless & Kathuria, 1993). SPSS software with its add on AMOS and Microsoft Excel was utilised to conduct descriptive statistics.

Inferential statistics, on the other hand, according to Babbie (1992) are used to obtain conclusions after conducting data analysis, hypothesis testing and validating and reliability testing on the collected data. With inferential statistics, the research tries to reach for conclusions that extend beyond the realm of descriptive statistics. The key benefit of inferential statistics lies in its ability to analyse and infer results from data which are based on random samples, taken from a population in order to deduce research hypotheses (Babbie, 1992; Lowry, 2014). The data analyses of each section of the questionnaire as well as the sample size requirements are discussed next.

3.4.1.1 Section A and Section B of the Questionnaire

Descriptive statistics were utilised to analyse the responses given in Sections A and B of the questionnaire. Section A captured the demographical data of the participating teachers and included: gender, age, teaching experience, type of school currently teaching at and province. In Section B details were given of the different types of ICTs accessible to participating teachers. The participants in this study indicated accessible ICTs from a predetermined list and also indicated how the accessible ICTs were currently being used. The questions were divided into three main categories namely: 1) In class for teaching; 2) For preparation and 3) For own professional development. A four-point Likert scale was utilised to indicate the level of usage for each category.

3.4.1.2 Section C of the Questionnaire

Section C of the questionnaire was based on the UTAUT construct and investigated the reasons why participating teachers were using ICT in the teaching and learning environment. According to Punch (2003) there are three main guidelines for analysing quantitative data. They are: creating variables; distributing variables across the sample; and creating relationships. Based on its ability to model latent variables for data screening and data analysis, SPSS software version 24 and its supplement AMOS version 24 were found to be the appropriate and the most suitable tools for analysing the quantitative data in this study. An SEM model incorporating both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) was done, using AMOS. In the SEM model, the EFA indicated possible underlying structures behind correlations and different factors (Brace, Snelgar & Kemp, 2012) whilst the CFA was conducted to confirm whether the theoretical factor structure could be supported (Kline, 2012).

A literature review of what constitutes as a good sample size for conducting SEM research revealed a variety of different opinions (Hogarty, Hines, Kromrey, Ferron & Mumford, 2005). General guidelines suggest that having at least 300 cases would be deemed acceptable for factor analysis (Tabachnick & Fidell, 2013), whilst according to Hair, Black, Babin and Anderson (2010) a sample size of 100 or greater would be sufficient. Ding, Velicer and Harlow (1995) consider a sample size between a 100 to 150 to be the minimum. The sample size of 191 for this study fits within the suggested range of the literature reviewed.

3.4.1.3 Section D of the Questionnaire

Section D of the questionnaire added a deeper level of understanding as to how the participating teachers integrated ICT. This part of the questionnaire was based on the SAMR model proposed by Puentedura (2012). Content analyses were used to make sense of the open-ended responses and the data were coded accordingly using predefined words and phrases linked to ICT and education.

3.4.1.4 Section E of the Questionnaire

Section E of the questionnaire portrayed the participating teachers' intention to use ICT versus their actual use of ICT. The use of SEM, with correlation coefficients, was proposed to establish whether correlations between the four UTAUT constructs and teachers' intention to use ICT exist. If any correlations did exist, investigations into how significant these correlations are, were performed.

3.5 RELIABILITY AND VALIDITY

3.5.1 Reliability

Reliability according to Cohen et al. (2011) is synonymous with dependability, consistency and replicability over time. This implies that comparable findings must be the result if research were performed on comparable groups of respondents in a comparable context. For this study, the Cronbach's Alpha was used to check the questionnaire's reliability by evaluating the internal consistency of the items for all four UTAUT constructs (Gliem & Gliem, 2003).

3.5.2 Validity

Validity according to Zohrabi (2013) is concerned with the fact that research conducted is credible and true and is evaluating what is supposed to evaluate. According to Cohen et al. (2011), this is basically when an instrument measures what it is intended to measure and they claim that it is a matter of degree rather than an ultimate state. This study investigated instrument validity by conducting convergent validity and discriminant validity tests which are also termed as construct validity (Trochim, 2006a). According to Cronbach and Meehl (1955) construct validity is the degree to which an instrument measures the construct it is intended to measure. These tests are discussed in detail under Sections 4.5.3.1 and 4.5.4.3 for the EFA and CFA, respectively.

3.6 ETHICAL CONSIDERATIONS

Ethical issues are concerned with human dignity during research (Cohen et. al., 2011, 2007). Hopf (2004, p. 334) states that:

> Under the keyword 'research ethics' it is usual in social sciences to group together all those ethical principles and rules in which it is determined – in a more or less binding and more or less consensual way – how the relationships between researchers on the one hand and those involved in sociological research on the other hand are to be handled. (Hopf, 2004, p. 334)

Terrell (2012) provides a list of ethical concerns for research that includes amongst others: 1) participation must be voluntary; 2) participants must be familiar with the purpose of the study; 3) the potential benefits of the study must be outlined to all participants and they must be informed that their privacy will be respected and 4) participants must know that they are entitled to a copy of the results.

In addressing Terrell's (2012) list of ethical concerns, I have created a Google Form with an introductory page, explaining to participants the purpose and modus operandi of my study, inviting them to complete the online questionnaire (e-survey) if they agreed to participate, making participation completely voluntary. For the English version of the e-survey please see https://goo.gl/forms/qtfKftQ2eqvvh0Rd2 and for the Afrikaans version please see https://goo.gl/forms/rpNUI2iXxhi9njst2 Additionally, participants were not being allowed to continue with the online questionnaire if they did not click on a tick box indicating that they had read and understood that participation was voluntary and anonymous. Likewise, to the online questionnaire, respondents completing the hard copies of the questionnaires, distributed at the mathematics seminar or conference, had to sign an informed consent letter attached to the questionnaire. The informed consent letter covered the standard measures expected of researchers in the social domain as listed by Denscombe (2010). This includes: 1) anonymity of respondents; 2) confidentiality; 3) the nature of the research and participants' involvement and 4) participants giving voluntary consent. Respondents will also be informed that a report on the findings of this study will be made available to them.

3.7 CHAPTER SUMMARY

As a critical realist, the researcher believes that a greater reality, free of our beliefs or ideas exists. Critical realism strives to learn about observable and non-observable constructs, free of events produced by them (Krauss, 2005). Utilising a post-positivistic critical realist paradigm, the researcher aims to bridge the gap between the sciences and the social sciences and realising that the results are fallible and not necessarily generalisable. In line with the aforementioned a quantitative approach was deemed to best answer the research questions of this study. Research methods included a discussion of the sampling and participants in the study. A hard copy questionnaire as well as an online survey was utilised to obtain as large a response as possible. In total 191 teachers completed the questionnaires (either online via the e-survey or a hard copy of the same questionnaire). For data analyses, both descriptive and inferential statistics was used to provide different insights into the nature of the data gathered. SPSS software with its add on AMOS and Microsoft Excel was utilised to conduct an SEM model.

Concerning the questionnaire, Section A captured the demographical data of the participating teachers, whilst in Section B the different types of ICTs accessible to participating teachers were recorded. Section C of the questionnaire was based on the UTAUT construct and investigated the reasons why participating teachers were using ICT in the teaching and learning environment. An attempt to understand at a deeper level how the participating teachers integrated ICT was made in Section D and in Section E participating teachers' intention to use ICT versus their actual use of ICT was captured. Reliability and validity concerns were addressed using Cronbach's Alpha and construct validity respectively. Finally, ethical issues were discussed and addressed according to Terrell's (2012) list of ethical concerns.

4. CHAPTER 4: FINDINGS AND RECOMMENDATIONS

4.1 INTRODUCTION

This chapter provides a systematic examination of the data generated via the methodology described in Chapter 3. The discussion is organised along the main findings of the questionnaire. These are:

1) Participating teachers' demographic information (Section A of the questionnaire).
2) Availability and current integration levels of ICTs by the participants (Section B of the questionnaire).
3) In-depth analysis of how ICTs are integrated into the teaching and learning of mathematics according to the SAMR model (Section D of the questionnaire).
4) Report and analysis of the UTAUT constructs, including results on the reliability of the measuring of the questionnaire items (Section C of the questionnaire).

4.2 DEMOGRAPHIC INFORMATION

Most of the participants were female (79%) and only 21% were male (refer to Section 3.3.1 for a full discussion). Most of the teachers were between 50 and 59 years old (29.32%). The majority of participating teachers taught mathematics at secondary schools during the last five years. At primary school level, the majority taught Grade five and/or Grade seven mathematics with (15.81% of the total), while only one participant (0.52%) indicated that he/she had taught Grade two mathematics in the past five years. The secondary school respondents were fairly evenly spread among grades 8, 9, 11 and 12, with most of them having taught Grade tens (55.50%) during the previous five years. The grade taught second most of all were Grade elevens (50.26%). For a complete overview of the number of participating teachers who taught each grade, refer to Table 4.1. Furthermore, it is also important to note that even if the participating teachers only taught mathematics to one grade in a specific year, the majority are likely to have taught mathematics to different grades during the previous five years.

Table 4.1: Grades taught by respondents during the last five years including 2017

Grade previously taught	Frequency	Percentage %
1	3	1.57%
2	1	0.52%
3	4	2.09%
4	20	10.47%
5	29	15.18%
6	28	14.66%
7	29	15.18%
8	84	43.98%
9	89	46.60%
10	106	55.50%
11	96	50.26%
12	88	46.07%

As projected, since most participants taught mathematics at secondary schools during the last five years, most of them are secondary school teachers. In the primary school, there has been a slight shift with the majority of participating teachers teaching Grade six and/or Grade seven mathematics (12.57% for both grades).

Table 4.2: Grades currently (2017) taught by respondents

Grade currently taught (2017)	Frequency	Percentage %
1	3	1.57%
2	0	0.00%
3	2	1.05%
4	14	7.33%
5	20	10.47%
6	24	12.57%
7	24	12.57%
8	56	29.32%
9	61	31.94%
10	69	36.13%
11	73	38.22%
12	70	36.65%

Within the secondary school the majority of participating teachers, teach in the FET (Grades ten to twelve) band. They mainly teach Grade elevens (38.22%). The number of participating teachers currently teaching mathematics (for all the different grades) can be viewed in Table 4.2.

As can be seen in Table 4.3, respondents predominantly teach at schools located in a city (68.06%). Considerably less (26.18%) teach in rural areas, with only eleven (5.76%) of respondents teaching at township schools.

Table 4.3: Schools' location where respondents teach

Location	Frequency	Percentage %
City	130	68.06%
Rural	50	26.18%
Township	11	5.76%

In general, the participating teachers teach at public schools: 89.53% of them teach at public schools and just 10.47% of them teach at private schools (refer to Table 4.4).

Table 4.4: Type of school where respondents teach

Type of school	Frequency	Percentage %
Private school	20	10.47%
Public school	171	89.53%

Finally, most of the participating teachers teach within the Gauteng province (45.03%) and secondly within the Western Cape (21.47%). The number of participating teachers currently teaching mathematics within the different provinces can be viewed in Table 4.5.

Table 4.5: Provinces where respondents teach

Province	Frequency	Percentage %
Gauteng	86	45.03%
Western Cape	41	21.47%
Eastern Cape	13	6.81%
North West	15	7.85%
Free State	7	3.66%
Limpopo	16	8.38%
KwaZulu-Natal	7	3.66%
Mpumalanga	5	2.62%
Northern Cape	1	0.52%

It should be noted here that whilst an attempt was made to distribute the e-survey link across South Africa, using various email lists obtained by the researcher. The majority respondents however, came predominantly from city schools where ICTs are readily available, especially in the two provinces namely Gauteng and the Western Cape. These two provinces both have intensive focus on ICT with various ICT implementation plans.

4.3 HOW ARE ICTs CURRENTLY BEING UTILISED BY MATHEMATICS TEACHERS?

Section B of the questionnaire was aimed at developing a deeper insight into what ICTs teachers can access and how they integrate these ICTs for the teaching and learning of mathematics. This section was broken down into four categories and they were: 1) availability of ICTs, 2) ICTs used for the teaching and learning of mathematics, 3) ICTs used in preparation for the teaching and learning of mathematics and 4) ICTs used for the teacher's own personal development. For Category 1 that identified the ICTs available, the participating teachers were given a predetermined list and were asked to indicate by "yes" or "no" if the particular ICT was available and/or accessible to them. In the remaining three categories (teaching and learning, preparation and personal development) the participating teachers were asked to rate on a four-point Likert scale, with 1 = "Never"; 2 = "Rarely"; 3 = "Sometimes" and 4 = "Often" how they specifically used each of the ICTs in the first category. For comparisons, Table 4.6 provides a brief summary of the top ten identified ICTs from each part of this section. Only the top ten in each category will be reported on in this chapter, for charts containing the full list of ITCs on each part of Section B please refer to Annexure D.

Table 4.6: Summary of the top ten identified ICTs in order

Spot	Available of ICTs	ICTs used most often in class for teaching	ICTs used most often for preparation	ICTs most often used for personal development
1	Personal Computer/Laptop	Personal Computer/Laptop	Personal Computer/Laptop	Personal Computer/Laptop
2	Microsoft Word	Data Projector	Microsoft Word	The Internet
3	E-Mail	Microsoft Word	Printer	Microsoft Word
4	Printer	Microsoft PowerPoint	The Internet	Microsoft Excel
5	The Internet	Printer	Microsoft Excel	Printer
6	Microsoft PowerPoint	Interactive Board	Microsoft PowerPoint	E-Mail
7	Microsoft Excel	The Internet	Scanner	YouTube Videos
8	Data Projector	Microsoft Excel	YouTube Videos	Microsoft PowerPoint
9	Scanner	YouTube Videos	Data Projector	Mobile Devices
10	YouTube Videos	Dynamic Mathematics Software	Dynamic Mathematics Software	Dynamic Mathematics Software

Notably the top ten ICTs that emerged in each category could all be related with educational functionality. The personal computer/ laptop came up on top in all four categories of Section B, followed by Microsoft Word (word processing software) in two of the categories and the data projector and Internet in the remaining categories. The result is in agreement with the literature as Buabeng-Andoh (2012) found that the hardware most frequently used by teachers was the computer, and the software mostly used for integration was word processing. This is also consistant with Becker, Ravitz and Wong (1999) who found that word processing software and internet browsing software were the most commonly used applications by teachers regardless of the subject they taught. Similarly, Slaouti and Barton (2007) also concluded that the ICT most commonly used by teachers was word-processing, PowerPoint and the internet. Lau and Sim (2008) in their study of ICT adoption among secondary school teachers in Malaysia found that teaching courseware (73%), presentation tools (43%), internet browsing (53%), and spreadsheets (32%) were the most frequently used. All of the ICTs mentioned here are present in the Table 4.6.

Stols et al. (2015) in their study amoung South African mathematics teachers also found that almost all of the participating teachers (95.2%) used their computers/laptops on either a weekly or a daily basis at their school for teaching purposes. Computers were also regularly used at home to prepare for school work, with almost 86% of the respondents using their computers to prepare for school work on either a daily (47.6%) or a weekly (38.1%) basis. Furthermore, according to Stols et al. (2015) the majority of the teachers used Microsoft Word (MSWord) to prepare lessons and Excel to capture marks. Jegede, Dibu-Ojerinde and Ilori (2007) also states that teachers are more proficient in word processing than any other computer application. This adds to the fact that software such as Microsoft Word is among the top three in all four categories of this study.

4.4 ICT INTEGRATION ACCORDING TO THE SAMR MODEL

Section D of the questionnaire added a deeper level of understanding as to how the participating teachers integrated ICT, by asking them to list the ICT they felt had the biggest impact on the teaching and learning of mathematics. Participants were further asked to then elaborate on their answer by explaining how they applied the particular ICT in the teaching and learning of mathematics. Content analyses were used to make sense of the open-ended responses and the data were coded according using predefined words and phrases linked to ICT and education. For the question: “what ICT has the biggest impact on the teaching and learning of mathematics”, a total of 284 responses were recorded as some participating teachers mentioned more than one ICT. For example, teachers stated a computer, data projector and interactive whiteboard were used in conjunction with each other. For a lengthier question asking teachers to describe how they used the particular ICTs, a total of 203 responses were captured as some teachers again mentioned more than one ICT. Of the 203 responses however, only 159 was deemed usable for analyses according to the SAMR model.

The SAMR model provides a tool for assessing and evaluating how ICT practices impacts a traditional classroom setting (Hos-McGrane, 2014; Lund, 2015; Myers, 2014; Puentedura, 2012; Tucker, 2013), and therefore, only replies that indicated specifically how the ICTs in question were applied in the classroom environment were coded. For example, replies such as “use it everyday” and “for introduction” were not coded, whilst replies such as “Use a computer to plan lesson” or “YouTube or Videos shown to learners” were coded. Data collected revealed the following results which are discussed under the categories of the SAMR model below.

4.4.1 ICTs with the biggest impact according to participating teachers

Participating teachers were asked to list the ICT that they felt had the biggest impact on the teaching and learning of mathematics. This was an open-ended question and responses often included more than one specific ICT, as many of the ICTs work in combination with each other. For instance, participating teachers would list a data projector, personal computer and Microsoft PowerPoint. A total of 278 ICTs were identified and by employing content analysis this was later categorised into twenty categories. Table 4.7 provides a summary of the categories identified together with the corresponding frequencies. The ICT perceived by participating teachers to have the biggest impact on the teaching and learning of mathematics was a data projector with 19.42% of the responses. Second in line was Dynamic Mathematics Software such as GeoGebra, Desmos and Autograph with 19.06% of the responses. Interactive whiteboards were third with 16.55% of the responses. Although data projectors are normally used in conjunction with interactive whiteboards, it is noteworthy to point out that many interactive whiteboards come with a built-in data projector and are therefore often perceived by teachers to be one thing.

Table 4.7: Summary of the categories identified together with the corresponding frequencies indicating use.

ICT	Frequency	Percentage %
Data projector	54	19.42%
Dynamic Mathematics Software	53	19.06%
Interactive Whiteboard	46	16.55%
Online video streaming services (YouTube)	24	8.63%
Personal computer/ laptop	20	7.19%
Microsoft office (Word, Excel, PowerPoint)	20	7.19%
Internet	17	6.12%
Document Camera / Visualizer	14	5.04%
Tablet, cell phone and apps	11	3.96%
Television	4	1.44%
White board/ Chalk board	3	1.08%
Printer	2	0.72%
Overhead projector	2	0.72%
Online feedback software (Google Forms and Kahoot)	2	0.72%
Learner Management Systems (Edmodo and Moodle)	1	0.36%
Video creation software (Explain Everything)	1	0.36%
Cloud storage (Google drive, Dropbox, Microsoft OneDrive)	1	0.36%
Scanner	1	0.36%
Casio Emulator	1	0.36%
E-books	1	0.36%

4.4.2 Substitution

In the substitution category an ICT acts as a direct tool, a substitute, with no functional change in the teaching and learning practices (Nkonki & Ntlabathi, 2016). It was evident from the data that the ICTs listed above were mainly just applied as a substitute for the old way of doing things. From the content analysis, it was gathered that 71.70% of the responses contained words or phrases including but not limited to:

- “PowerPoint and PowerPoint with text and images”.
- “Visual presentation of the mathematics”.
- “Data projector with PowerPoint”.
- “Use GeoGebra to show learners’ graphs”
- “Use a computer to plan lesson”.
- “Use interactive whiteboard for all my lessons”.
- “YouTube or Videos shown to learners”.
- “Drafting exam papers and capturing learner data”.
- “Visualizer with data projector to show learners”.

Further analysis provided explicit examples of how teachers were integrating ICTs. For example, the participating teachers used a data projector in combination with an interactive whiteboard, document camera or personal computer (running Microsoft PowerPoint) to display typed up mathematics lessons in the same way that they could have written it on the traditional chalkboard or whiteboard. The following excerpts suggested no functional changes in the teaching and learning methods and tasks:

- “I use a computer and PowerPoint to display prepared lessons in my classroom.”
- “Show all workings step by step for learners while I can track learners' reactions and so they can see exactly how, for example, a protractor works.”
- “Show different methods of calculations.”
- “I prepare the lesson on my laptop by using Word and Equations. Then I display it through digital projector on plain white board where I can make notes on the board.”

- "I use PowerPoint and streaming from a tablet."
- "I use it (interactive whiteboard and data projector) throughout the period for writing, examples and graphs."
- "I do the problems with the learners, sometimes using one of their books to show how marks are allocated in examinations. I illustrate how the calculator works visually and I show a memorandum of the homework whilst walking through the class and checking for homework."
- "Explanation using ICT instead of blackboard means I don't have to redraw all the graphs. For example, use textbook directly below visualizer."
- "I use the package (Microsoft Office) to type my documents, class lists etc. I also use PowerPoint to show certain concepts."
- "I use it to print worksheets".

Furthermore, participating teachers also indicated that they employed videos in their lessons. The use of online streaming services such as YouTube was number four on the biggest impact list. However, this strengthens the case that whilst online videos are an addition to the classroom, it is just a substation for the teacher talking and explaining the mathematical concepts. The following excerpts taken verbatim from the data, supports this finding:

- "Video is played, paused and explained. Then I go over to data projector with revision of the concept and application with examples."
- "Start the lesson with YouTube video and then fill it up"
- "The time factor for composing lessons is missing, therefore I use DVDs and YouTube."
- "YouTube videos, PowerPoint presentations, providing summaries of work."
- "Quickly get a YouTube video to for instance illustrate the relationship between volume of cube and pyramid or the application of data when the basics was covered."

The findings from the content analyses indicates that the substitution category was by far the largest of the four with the vast majority of entries (57.59%) falling within this category. As previously stated, the SAMR model has been applied to study ICT use in fields such as higher education (Romrell et al., 2014), but it is not currently represented in the existing literature (Hamilton et al., 2016). After extensive review of the literature no specific evidence could be found of the application of the SAMR model in mathematics education in South Africa. One study that focused on the adoption of the SAMR model to assess ICT Pedagogical Adoption at a university level concurred with the results of this study. Findings from Jude et al. (2014) indicated that the most commonly applied category was substitution with 74.4% of the lecturers using ICT for preparing lecture notes, assignments and examinations. This finding, as is the case in this study, collaborated with the fact that the personal computers/laptops were the most highly (84.6%) used ICT for teaching and learning (Jude et al., 2014). Furthermore, according to Jude et al. (2014) to substitute the traditional chalkboard, 48.5% of the lecturers were using LCD projectors to present their lectures. The latter is also the case in this study, as many of the participating teachers indicated that they used ICTs to show information. In a more recent study Geer, White, Zeegers, Au and Barnes (2017) found that many of the participating teachers in their study indicated that there had been little to no change in their pedagogy after integrating ICT, suggesting that they were in the substitution stage of the SAMR model. For a detailed discussion on the substitution category refer to Section 2.6.2.1.

4.4.3 Augmentation

With augmentation, technology acts as a direct tool, a substitute with functional improvements in the teaching and learning practices. In the teaching and learning environment, the same things are done with technology but there are however, minor improvements Fabian and MacLean (2014). For example, teachers improved from displaying mathematics using Microsoft PowerPoint or YouTube videos by adding the ability to show how variables of a function act on its graph using Dynamic Mathematics Software such as GeoGebra, Desmos and Autograph. Although this function could be performed on the traditional chalkboard or whiteboard, by drawing a multitude of sketches, the use of ICT has improved how it is done and with a great amount of efficiency. Several excerpts from the data showcased the integration of Dynamic Mathematics Software as part of a mathematics lesson:

- “Autograph or GeoGebra makes calculus so visual, kids understand the whole tangent to the circle idea as they see how that tangent moves across the graph!”
- “Interactive sketches on mathsisfun.com (website) to illustrate relationship with quadrants and graphs in trigonometry”
- “Graph to derive influence of certain parameters in functions.”
- “Use PowerPoint and GeoGebra to show and explain mathematics to learners.”
- “By using GeoGebra to explain the effects of a, p and q in graphs.”
- “GeoGebra to show the differences of parameters. Slides that are applied to the basic concepts. The use of scanner projector for the textbook reference etc. There are so many!”

The following two extracts from the data clearly indicate that some teachers were functioning at the augmentation level.

- “What I write is being projected. I can work and use highlights and colours and it saves time not to erase boards and I can electronically make my lesson available to students.”
- “Share my prepared notes with my learners via Shareit, explain most geometric figures with ease.”

Overall, the content analyses indicated that 23.90% of the participating teachers were using ICTs at this level. Whilst several ICTs are providing some minor improvements it does not necessarily translate into more learner interaction and engagement. Making a lesson available to learners online does not inevitably lead to learners’ actually going online and engaging with the materials. There should be measures in place to check that the learners are using these lessons and materials. For example, giving learners a task of watching a lesson, summarising what they have viewed and sharing it on an online forum or blog etc. would be an example of testing that they are engaging with the content. This will lead to breaking that imaginary dotted line boundary of the SAMR model and illustrates a movement from enriching traditional classroom activities into a territory where the teaching and learning of mathematics are reliant upon technology and the educational experience is transformed by the activity itself. This is something that happens in the modification and redefinition categories of the SAMR model. Puentedura (2012) points out that modification and redefinition are the highest levels of the SAMR model and the most difficult to attain.

Burns-Sardone (2014) used the SAMR model to help assess pre-service teacher's readiness to effectively implement a BYOD (Bring Your Own Device) programme. In this study, the BYOD lesson plans developed by the pre-service teachers were evaluated in terms of SAMR. Of 68 assignments, 25 were determined to be at the substitution level (36.76%), 35 at the augmentation level (51.47%), 5 at the modification level (7.35%), and only three at the redefinition level (4.41%), suggesting that even "technology natives" of the current generation are challenged by technology integration tasks. Although the findings were based on pre-service teachers, these results concur with the finding of this research.

4.4.4 Modification

In the modification category, the ICT allows the nature of the teaching and learning to change significantly, and to be redesigned to fit a potentially different, richer outcome. Hamilton et al. (2016) provides an excellent example of this. They explain that if a teacher in a secondary science class, modifies how learners are taught of the concept of light, from showing the traditional diagram of light traveling to a more interactive computer simulation of light, where the learners (being actively involved) can change the variables it would form part of modification as the learning is learner directed. Very little of the participating teachers are or have been functioning at this level. There were only three instances identified from the 159 responses that fitted the example given above. They include:

- "Learners can play with GeoGebra and make different discoveries."
- "Allow learners to explore the connection between equations and graphs."
- "Learners have GeoGebra on their tablets and use it themselves."

It should be noted that the emphasis here is on creating a teaching and learning environment that is predominantly learner-centred.

4.4.5 Redefinition

With redefinition, ICT allows for the creation of new tasks which were previously inconceivable, a remix and redesign process, a total transformation of one's practice (Fabian & MacLean, 2014). Referring to the example of Hamilton et al. (2016) in the modification category, according to Lund (2015), at the redefinition level the teacher can ask learners to create a multimedia audio or video project of their finding from engaging with the interactive simulations and present it to the class either in class or on an online forum, blog etc. This task would have been previously inconceivable without ICTs.

The data, however, did not provide any evidence of changes that would be effected at this level of aligning. It is worth noting that, according to Jude, Kajura and Birevu, (2014), Lund (2015), Myers (2014) and Puentedura (2012), redefinition is the highest level of the SAMR model and the most difficult to attain. As previously mentioned in the study of Burns-Sardone (2014) only 4.41% of the participating pre-service teachers could reach this level, indicating how difficult it is to attain. In a study by Nkonki and Ntlabathi (2016) that looked at lecturers' use of one specific ICT at a higher education institution, it also emerged that none of the data provided evidence of changes that would be effected at the redefinition level of aligning teaching and learning practices. They concur that, "with the redefinition level, most, if not all the lecturers had not reached this transformation level in their design of tasks and methods of teaching and learning". This study also emphasised the difficulty of attaining the redefinition level.

4.5 REASONS FOR INTEGRATING ICTs IN TEACHING AND LEARNING (UTAUT CONSTRUCTS)

Section C of the questionnaire was based on the UTAUT constructs and investigated the reasons why participating teachers were using ICT in the teaching and learning environment. The items in this section of the questionnaire measured participating teachers' Performance Expectancy, Effort Expectancy, Social Influences and Facilitating Conditions regarding the use of ICT. The participating teachers were asked to select a number that best described their agreement or

disagreement with each statement on a five-point Likert scale, with 1 = “Disagree”; 2 = “Somewhat Disagree”; 3 = “Neutral”; 4 = “Somewhat Agree” and 5 = “Agree”.
In this next section, the following items will be discussed:

- Medians and frequencies for Likert-type variables.
- Means and standard deviations for continuous variables.
- Data Screening.
- Exploratory Factor Analysis (EFA).
- Confirmatory Factor Analysis (CFA).
- Structural Equation Modelling (SEM).

4.5.1 Medians and frequencies for Likert-type variables

Since Likert-type items are classified as ordinal data, descriptive statistics such as the mean (measure of location) and standard deviation (measure of spread) are not recommended. Descriptive statistics appropriate for ordinal data are the mode or the median (measure of location) and the frequencies (measure of spread). Tables 4.8 to 4.11 report the medians (averages of the responses on the five-point Likert scale) and frequencies for all items respectively, since it is good practice to report them in studies using structural equation modelling (SEM).

Although it was just mentioned that Likert-type items are classified as ordinal data, descriptive statistics such as the mean and standard deviation are not recommended. However, Likert scale items, which have an interval measurement scale, can be created by calculating a composite score (which can include an average and/or a sum) for several Likert-type ordinal items. Once this has been done, descriptive statistics such as the mean and the standard deviation can be computed. Composite scores were computed for items loading onto the same factor and the results, for each factor, are then summarised in a histogram below each table. It should be noted that these histograms should not be interpreted similarly to bar graphs where one only simply investigates which bar is the highest across from which Likert value (1, 2, 3, 4 or 5). These histograms have taken the information of items building onto the same factor and summarise the responses per factor. For example, in Figure 4.1, instead of giving three separate bar graphs for questions 9.1, 9.5, 9.9, 9.13, 9.17, 9.20, 9.21, 9.22, 9.24, 9.26, 9.27 and 9.28, respectively, the information has been consolidated (a composite score was calculated) for the factor 'Performance Expectancy' in SPSS and is presented as a histogram. The way to interpret these histograms, is to investigate their shape. If a histogram is symmetric, it means that the majority of responses, for a factor (such as 'Performance Expectancy') are around the midpoint of the Likert scale. If the histogram is skewed to the left, it means that the majority of the responses were on the higher end of the Likert scale. On the other hand, if the histogram is skewed to the right, it means that the majority of the responses were on the lower end of the Likert scale.

4.5.1.1 Performance Expectancy construct

Table 4.8: Median and frequencies for Performance Expectancy construct

Item no.	Item	Median	Frequencies				
			Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree
9.1	ICT is useful for teaching graphs.	14	4	10	14	29	134
9.5	ICT is useful for teaching statistics.	30	9	12	30	44	96
9.9	ICT is useful for teaching calculus.	40	11	16	40	46	78
9.13	ICT is useful for teaching geometry.	8	8	8	5	34	136
9.17	ICT is useful for teaching analytical geometry.	36	8	15	36	43	89
9.20	ICT is useful for teaching algebra.	36	13	25	36	43	74
9.21	Using ICT to teach mathematics in the classroom will enhance learners' understanding.	37	13	16	37	41	84
9.22	Using ICT mathematics concepts could be explained in a way that learners grasp the concepts quicker than they would have if conventional (board and chalk) methods were used.	40	7	16	40	45	83
9.24	Using ICT to teach mathematics in the classroom will make it easier to explain difficult concepts.	24	7	20	24	61	79
9.26	Using ICT to teach mathematics in the classroom saves time	22	11	20	22	40	98
9.27	Using ICT for teaching in the classroom would increase my productivity.	23	8	19	23	49	92
9.28	If I use ICT for teaching in the classroom, I will increase my employment opportunities.	31	8	19	31	41	92

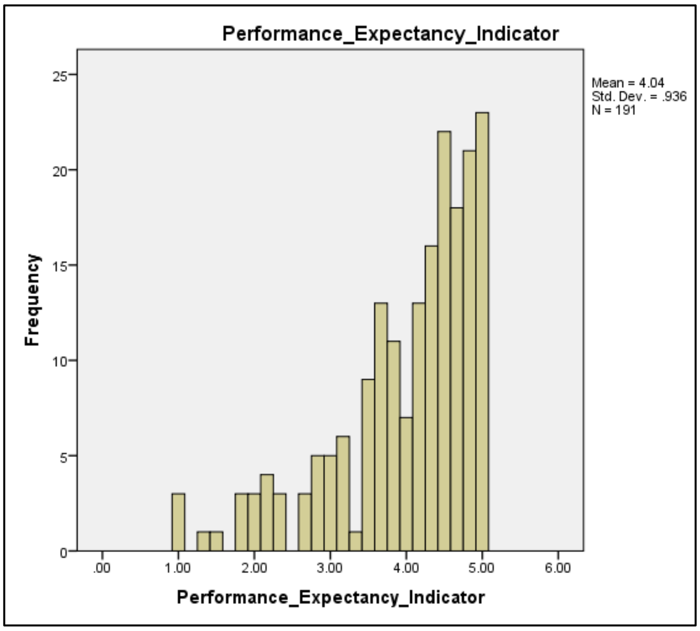

Figure 4.1: Histogram for Performance Expectancy construct

From Figure 4.1 it appears as if the histogram is skewed to the left, indicating that the majority of responses were at the higher end of the Likert scale for the factor ‘Performance Expectancy’. This is also evident from the fact that the mean is greater than the midpoint value of three. Thus, most participants somewhat agreed or agreed with the questions on Performance Expectancy.

4.5.1.2 Effort Expectancy construct

Table 4.9: Median and frequencies for Effort Expectancy construct

Item no.	Item	Median	Frequencies				
			Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree
9.2	It is easy to use ICT for teaching graphs.	26	7	12	26	42	104
9.6	It is easy to use ICT for teaching statistics.	40	10	17	40	47	77
9.10	It is easy to use ICT for teaching calculus.	45	15	29	45	45	57
9.14	It is easy to use ICT for teaching geometry.	25	11	16	25	43	96
9.18	It is easy to use ICT for teaching analytical geometry.	40	13	18	47	40	73
9.19	It is easy to use ICT for teaching algebra.	39	16	27	39	42	67
9.23	In general, it is easy to use ICT for teaching mathematics	30	12	24	30	60	65
9.25	Learning to use ICT to teach mathematics in the classroom would be easy for me	26	7	21	26	44	93

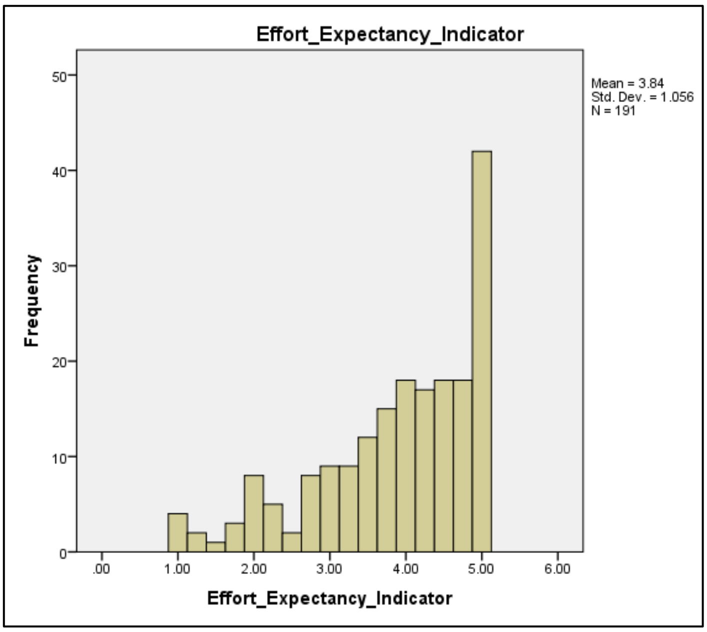

Figure 4.2: Histogram for Effort Expectancy construct

From Figure 4.2 it emerges that the histogram is skewed to the left, indicating that the majority of responses were at the higher end of the Likert scale for the factor ‘Effort Expectancy’. This is also evident from the fact that the mean is greater than the midpoint value of three. Thus, most participants somewhat agreed or agreed with the questions on Effort Expectancy.

4.5.1.3 Social Influences construct

Table 4.10: Median and frequencies for Social Influences construct

Item no.	Item	Median	Frequencies				
			Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree
9.3	My HOD or Subject head thinks that I should use ICT for teaching mathematics in the classroom.	34	20	13	34	42	82
9.7	My principal thinks that I should use ICT for teaching mathematics in the classroom.	36	23	21	36	36	75
9.11	The school governing body thinks that I should use ICT for teaching mathematics in the classroom.	29	22	26	38	29	76
9.15	My colleagues think that I should use ICT for teaching mathematics in the classroom.	39	20	18	40	39	74

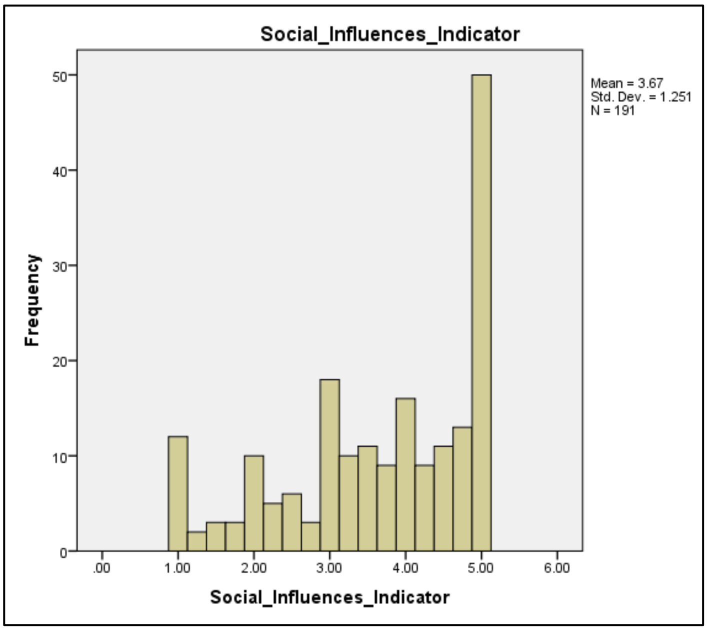

Figure 4.3: Histogram for Social Influences construct

From Figure 4.3 it appears as if the histogram is skewed to the left, indicating that the majority of responses were at the higher end of the Likert scale for the factor ‘Social Influences’. This is also evident from the fact that the mean is greater than the midpoint value of three Thus, most participants somewhat agreed or agreed with the questions on Performance Expectancy.

4.5.1.4 Facilitating Condition construct

Table 4.11: Median and frequencies for Facilitating Condition construct

Item no.	Item	Median	Frequencies				
			Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree
9.4	I have the resources necessary to use ICT to teach mathematics in the classroom.	26	21	14	26	49	81
9.8	I have the knowledge necessary to use ICT for teaching mathematics in the classroom.	26	12	26	25	58	70
9.12	It is possible for me to use ICT to teach mathematics in the classroom.	19	15	19	17	37	103
9.16	A specific person (or group) would be available for assistance with difficulties when using ICT to teach mathematics in the classroom.	37	33	37	32	43	46

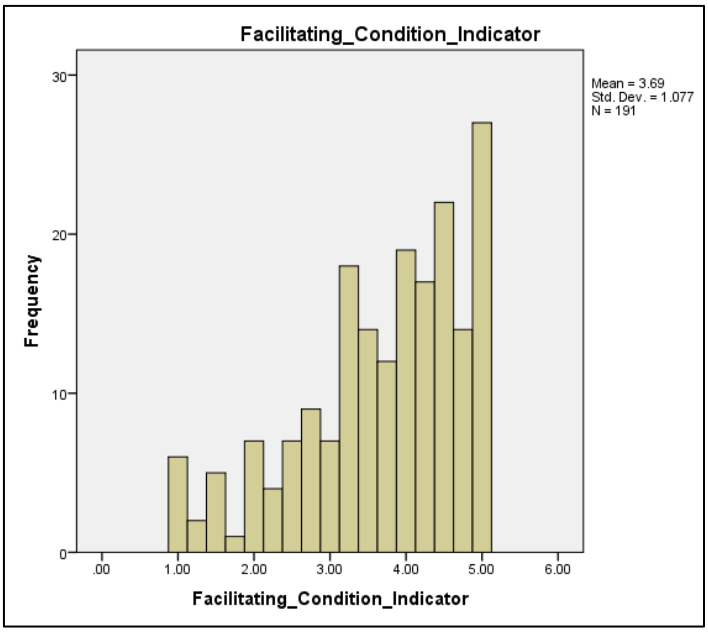

Figure 4.4: Histogram for Facilitating Condition construct

From Figure 4.4 it appears as if the histogram is skewed to the left, indicating that the majority of responses were at the higher end of the Likert scale for the factor 'Facilitating Conditions'. This is also evident from the fact that the mean is greater than the midpoint value of three. Thus, most participants somewhat agreed or agreed with the questions on Performance Expectancy.

4.5.2 Data Screening

Data collected underwent a screening process consisting of many steps, to ensure that subsequent analysis is based on a complete dataset that is void of any issues such as incomplete or unengaged answers. Descriptive and reliability statistics were implemented using SPSS while for the reporting of charts and similar illustrations Microsoft Excel, or SPSS AMOS were used.

4.5.2.1 Missing values

According to Schlomer, Bauman and Card (2010) there exists a possibility that respondents might neglect some questions or choose not to answer them, possibly due to stress, fatigue, sensitivity or lack of information. This data, or lack of it, is termed “missing data”. For this study, a missing data analysis was done to check whether values are missing in a random way or in a non-random way. Little’s MCAR test was run where MCAR stands for Missing Completely at Random (which is desirable) (Little, 1988). If the p-value of Little’s MCAR test is less than 0.05, then the data is not missing in a random way (undesirable) and if the p-value of Little’s MCAR test is greater than 0.05, then the data is missing in a random way (which is desirable) (Little, 1988). In this study however, SPSS was unable to run Little’s MCAR test, since there were no missing values in the data. See Annexure E for the list that shows there were no missing values in the data.

4.5.2.2 Outliers

One of the advantages of using multiple answer questions rather than allowing text input is to reduce participants' error such as entering incorrect or inaccurate data. Moreover, as the largest part of the questionnaire uses a Likert scale type of questions, outliers would have a lower chance of occurring as the user selects from pre-entered options.

4.5.3 Exploratory Factor Analysis (EFA)

Now that data screening is done, the next step was to carry out an exploratory factor analysis (EFA). EFA enables the investigation of possible underlying structures behind correlations between different factors (Brace, Snelgar & Kemp, 2012). Using SPSS, EFA can be run utilising data of measurement level that is ratio, interval, or ordinal.

For an EFA, the first step is to measure the sampling adequacy using the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) (Kaiser, 1970). Kaiser (1974) stated that KMO values below 0.5 are unacceptable and, in such a case, the researcher should rethink which variables to include in the EFA or collect more data. For a more specific breakdown of KMO values, the reader is referred to Hutcheson and Sofroniou (1999) where they stated that any KMO values ranging in the 0.60's are mediocre, those ranging in the 0.70's are middling, those ranging in the 0.80s are meritorious and those equalling 0.9 or higher are marvellous. For Question 9 of the questionnaire it was believed that there were four factors, namely, *performance expectancy*, *effort expectancy*, *social influences* and *facilitating condition*. An EFA was done on Question 9 in order to check whether there were in fact four factors or not. It should be noted that the researcher believed that Question 9.29 is about *behavioural intention*, which is not one of the factors listed above, and should this observation be correct, it shouldn't load highly onto any of the factors.

Table 4.12: Measure of sampling adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.935
Bartlett's Test of Sphericity	Approx. Chi-Square	5845.542
	Df	406
	Sig.	0.000

From Table 4.12 it can be seen that the KMO value equals 0.935 which according to Hutcheson and Sofroniou (1999) is marvellous. Bartlett's test of sphericity is always presented with the KMO output and the corresponding p-value should be significant. From Table 4.12 it can be seen that the p-value is given as 0.000 (which, in fact, indicates that the p-value < 0.001), which indicates that it is significant which, in turn, means that the correlations between the variables differ significantly from zero (Field, 2014, p. 685). Next, we move on to the SPSS output titled ‘Total Variance Explained’ and find that four factors have indeed been extracted. This can be seen from Table 4.13 and from the screen plot in Figure 4.5 where it can be seen that four of the eigenvalues are greater than one (Field, 2014, p. 697). Factor 1 explains 58.3% of the total variance which is much more than the other factors which explain 6% (Factor 2), 4.4% (Factor 3), 3.8% (Factor 4) of the total variance, respectively.

Table 4.13: Extraction of factors

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	16.9	58.3	58.3	16.9	58.3	58.3
2	1.8	6.4	64.7	1.8	6.4	64.7
3	1.3	4.4	69.1	1.3	4.4	69.1
4	1.1	3.8	72.9	1.1	3.8	72.9
5	1.0	3.4	76.2			
6	0.8	2.7	79.0			
7	0.7	2.4	81.4			
8	0.6	2.0	83.3			
9	0.5	1.7	85.0			
10	0.4	1.5	86.5			
11	0.4	1.4	87.9			
12	0.4	1.4	89.3			
13	0.4	1.3	90.6			
14	0.3	1.1	91.7			
15	0.3	1.0	92.7			
16	0.3	1.0	93.7			
17	0.3	0.9	94.6			
18	0.3	0.9	95.5			
19	0.2	0.7	96.1			
20	0.2	0.6	96.8			
21	0.2	0.6	97.4			
22	0.2	0.6	98.0			
23	0.1	0.4	98.4			
24	0.1	0.4	98.8			
25	0.1	0.4	99.1			
26	0.1	0.3	99.4			
27	0.1	0.2	99.6			
28	0.1	0.2	99.8			
29	0.1	0.2	100.0			

Extraction Method: Principal Component Analysis.

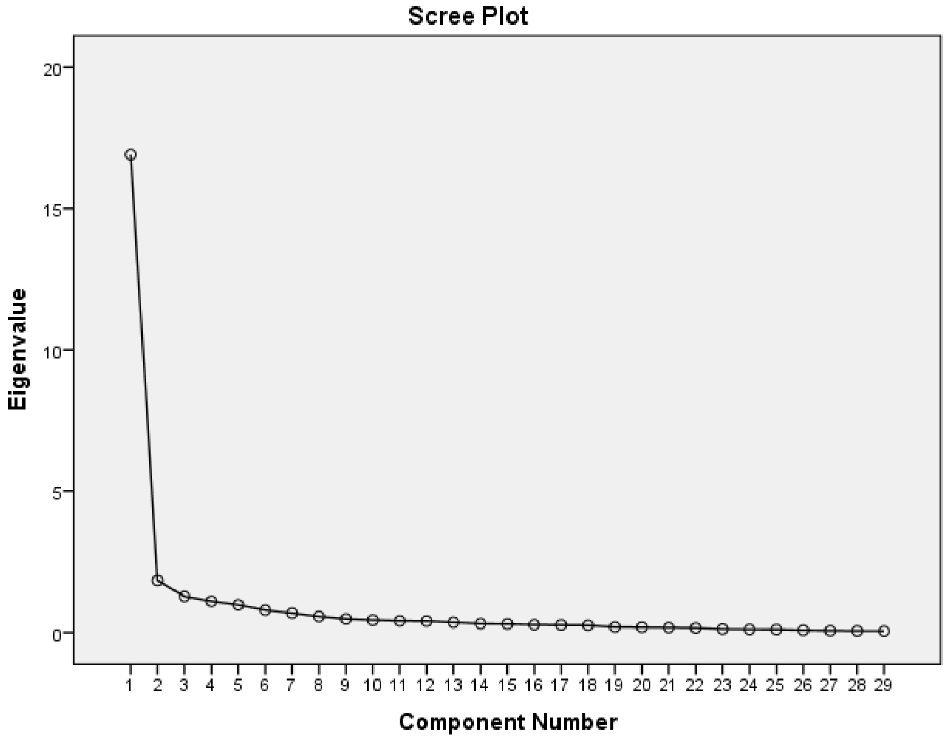

Figure 4.5: Screen plot of the EFA

The rotated component matrix in Table 4.14 shows the factor loadings for each variable. Orthogonal rotation (more specifically varimax) was used, since it is believed that the four factors, namely performance expectancy, effort expectancy, social influences and facilitating conditions are uncorrelated factors (Field, 2014, p. 684). Grey shading is used in Table 4.14 in order to show onto which factors the items are loading the highest. As suspected, Question 9.29 doesn't load highly onto any of the factors with loadings of 0.519, 0.437, 0.417 and 0.200 (from highest to lowest), so no grey shading is used, since it is believed to stand on its own to represent *behavioural intention*. From Table 4.14 it can clearly be seen that four factors have emerged. As suspected, Questions 9.3, 9.7, 9.11 and 9.15 load onto the same factor (social influence) which the researcher expected. Questions 9.21, 9.22, 9.24, 9.26, 9.27 and 9.28 load onto the same factor (performance expectancy) which the researcher expected. There is one other question loading onto this factor (Question 9.25), however, the loadings are not high for any of the factors and the researcher believes this item belongs with the factor *effort expectancy* which is reported on next. As suspected, Questions 9.10, 9.18, 9.19

and 9.23 load onto the same factor (effort expectancy) which the researcher expected. There are some other items loading onto this factor that were not expected to, however, these loadings are low. What was not expected by the researcher was the following: the researcher expected that Questions 9.4, 9.8, 9.12 and 9.16 would load onto the same factor *facilitating condition*, which they didn't. However, when investigating the loadings onto the other factors, the highest loading for all the questions were low (with the highest loading being 0.532). Later in this study, a confirmatory factor analysis was done to investigate this issue further.

Table 4.14: Factor loadings

Rotated Component Matrix[a]

	Component			
	1	**2**	**3**	**4**
Q9.19: It is easy to use ICT for teaching algebra	0.820	0.226	0.145	0.315
Q9.20: ICT is useful for teaching algebra	0.741	0.093	0.161	0.401
Q9.10: It is easy to use ICT for teaching calculus	0.740	0.354	0.239	0.237
Q9.18: It is easy to use ICT for teaching analytical geometry	0.671	0.466	0.231	0.267
Q9.23: In general, it is easy to use ICT for teaching mathematics	0.602	0.364	0.385	0.321
Q9.9: ICT is useful for teaching calculus	0.574	0.390	0.264	0.361
Q9.8: I have the knowledge necessary to use ICT for teaching mathematics in the classroom	0.532	0.454	0.371	0.192
Q9.17: ICT is useful for teaching analytical geometry	0.511	0.494	0.265	0.318
Q9.1: ICT is useful for teaching graphs	0.094	0.707	0.250	0.406
Q9.2: It is easy to use ICT for teaching graphs	0.388	0.702	0.180	0.317
Q9.5: ICT is useful for teaching statistics	0.382	0.678	0.204	0.237
Q9.6: It is easy to use ICT for teaching statistics	0.491	0.676	0.237	0.181
Q9.14: It is easy to use ICT for teaching geometry	0.490	0.596	0.246	0.301
Q9.13: ICT is useful for teaching geometry	0.205	0.581	0.318	0.357
Q9.12: It is possible for me to use ICT to teach mathematics in the classroom	0.237	0.526	0.518	0.159
Q9.7: My principal thinks that I should use ICT for teaching mathematics in the classroom	0.160	0.176	0.835	0.243
Q9.11: The school governing body thinks that I should use ICT for teaching mathematics in the classroom	0.235	0.138	0.813	0.264
Q9.15: My colleagues think that I should use ICT for teaching mathematics in the classroom	0.218	0.190	0.796	0.276
Q9.3: My HOD or Subject head thinks that I should use ICT for	0.169	0.270	0.754	0.253

teaching mathematics in the classroom				
Q9.4: I have the resources necessary to use ICT to teach mathematics in the classroom	0.162	0.499	0.529	0.227
Q9.29: I intent to use ICT to teach mathematics in the classroom in the next 6 months	0.200	0.417	0.519	0.437
Q9.16: A specific person (or group) would be available for assistance with difficulties when using ICT to teach mathematics in the classroom	0.424	0.213	0.458	0.025
Q9.27: Using ICT for teaching in the classroom would increase my productivity	0.308	0.335	0.221	0.772
Q9.28: If I use ICT for teaching in the classroom, I will increase my employment opportunities	0.232	0.323	0.275	0.729
Q9.22: Using ICT mathematics concepts could be explained in a way that learners grasp the concepts quicker than they would have if conventional (board and chalk) methods were used	0.311	0.178	0.341	0.726
Q9.26: Using ICT to teach mathematics in the classroom saves time	0.289	0.337	0.196	0.722
Q9.24: Using ICT to teach mathematics in the classroom will make it easier to explain difficult concepts	0.314	0.336	0.299	0.694
Q9.21: Using ICT to teach mathematics in the classroom will enhance learners' understanding	0.498	0.121	0.376	0.548
Q9.25: Learning to use ICT to teach mathematics in the classroom would be easy for me	0.480	0.461	0.187	0.489

4.5.3.1 Reliability and Validity

One possible approach to ensuring the minimum level of measurement error is to investigate properties of the measures that were developed to gain confidence that they are doing their job properly (Field, 2014, p.885). Two important properties of measures to investigate are validity and reliability. After the EFA presented above, a number of reliability and validity tests were run; to ensure that the instrument used to collect the data was reliable and that the data could be used.

4.5.3.1.1 Reliability

To ensure the reliability of the measures used in this study, Cronbach's alpha values for construct items were investigated (see Table 4.15). All constructs had Cronbach's alpha values well above the cut-off point of 0.7 (Osborne & Waters 2002, Tavakol & Dennick 2011).

Table 4.15: Cronbach Alpha values for the exploratory factor analysis

Component number from Table 4.14	Question numbers	Cronbach Alpha
1	9.8, 9.9, 9.10, 9.17, 9.18, 9.19, 9.20, 9.23	0.944
2	9.1, 9.2, 9.5, 9.6, 9.12, 9.13, 9.14	0.922
3	9.3, 9.4, 9.7, 9.11, 9.15, 9.16, 9.29	0.907
4	9.21, 9.22, 9.24, 9.25, 9.26, 9.27, 9.28	0.941

4.5.3.1.2 Validity

Two types of construct validity were investigated: convergent validity and discriminant validity. Convergent and discriminant validity are subcategories of construct validity and, if you have evidence that you have both convergent and discriminant validity, then you will have construct validity (Trochim, 2006a). Convergent validity shows that items that load onto the same factor are in fact related. This can be tested by calculating Spearman correlation coefficients on the items loading on the same factors and checking that these correlations are high, i.e. close to -1 or close to +1. Discriminant validity, on the other hand, shows that items that do not load onto the same factor are in fact not related. This can be tested by calculating Spearman correlation coefficients since items that do not load onto the same factors should have lower correlations than those loading onto the same factors. Firstly, Spearman correlations coefficients are calculated and interpreted for convergent validity.

4.5.3.1.2.1 Convergent validity

Table 4.16: Correlations for Component number 1 of the EFA

		Q9.8	Q9.9	Q9.10	Q9.17	Q9.18	Q9.19	Q9.20	Q9.23
Q9.8	Correlation	1.000	.604**	.701**	.478**	.602**	.623**	.494**	.753**
	p-value		0.000	0.000	0.000	0.000	0.000	0.000	0.000
Q9.9	Correlation	.604**	1.000	.839**	.727**	.660**	.622**	.589**	.618**
	p-value	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Q9.10	Correlation	.701**	.839**	1.000	.641**	.749**	.728**	.601**	.763**
	p-value	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Q9.17	Correlation	.478**	.727**	.641**	1.000	.815**	.625**	.635**	.559**
	p-value	0.000	0.000	0.000		0.000	0.000	0.000	0.000
Q9.18	Correlation	.602**	.660**	.749**	.815**	1.000	.753**	.622**	.676**
	p-value	0.000	0.000	0.000	0.000		0.000	0.000	0.000
Q9.19	Correlation	.623**	.622**	.728**	.625**	.753**	1.000	.877**	.725**
	p-value	0.000	0.000	0.000	0.000	0.000		0.000	0.000
Q9.20	Correlation	.494**	.589**	.601**	.635**	.622**	.877**	1.000	.645**
	p-value	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Q9.23	Correlation	.753**	.618**	.763**	.559**	.676**	.725**	.645**	1.000
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.16 It can be seen that all the items loading onto the first component are positively correlated and they are all significantly correlated at a 1% level of significance.

Table 4.17: Correlations for Component number 2 of the EFA

		Q9.1	Q9.2	Q9.5	Q9.6	Q9.12	Q9.13	Q9.14
Q9.1	Correlation	1.000	.681**	.584**	.546**	.487**	.470**	.527**
	p-value		0.000	0.000	0.000	0.000	0.000	0.000
Q9.2	Correlation	.681**	1.000	.569**	.660**	.537**	.432**	.686**
	p-value	0.000		0.000	0.000	0.000	0.000	0.000
Q9.5	Correlation	.584**	.569**	1.000	.818**	.483**	.466**	.578**
	p-value	0.000	0.000		0.000	0.000	0.000	0.000
Q9.6	Correlation	.546**	.660**	.818**	1.000	.482**	.438**	.691**
	p-value	0.000	0.000	0.000		0.000	0.000	0.000
Q9.12	Correlation	.487**	.537**	.483**	.482**	1.000	.427**	.503**
	p-value	0.000	0.000	0.000	0.000		0.000	0.000
Q9.13	Correlation	.470**	.432**	.466**	.438**	.427**	1.000	.557**
	p-value	0.000	0.000	0.000	0.000	0.000		0.000
Q9.14	Correlation	.527**	.686**	.578**	.691**	.503**	.557**	1.000
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.17 It can be seen that all the items loading onto the second component are positively correlated and they are all significantly correlated at a 1% level of significance.

Table 4.18: Correlations for Component number 3 of the EFA

		Q9.3	Q9.4	Q9.7	Q9.11	Q9.15	Q9.16	Q9.29
Q9.3	Correlation	1.000	.530**	.720**	.736**	.736**	.436**	.526**
	p-value		0.000	0.000	0.000	0.000	0.000	0.000
Q9.4	Correlation	.530**	1.000	.461**	.492**	.476**	.419**	.601**
	p-value	0.000		0.000	0.000	0.000	0.000	0.000
Q9.7	Correlation	.720**	.461**	1.000	.814**	.782**	.389**	.535**
	p-value	0.000	0.000		0.000	0.000	0.000	0.000
Q9.11	Correlation	.736**	.492**	.814**	1.000	.730**	.389**	.539**
	p-value	0.000	0.000	0.000		0.000	0.000	0.000
Q9.15	Correlation	.736**	.476**	.782**	.730**	1.000	.431**	.556**
	p-value	0.000	0.000	0.000	0.000		0.000	0.000
Q9.16	Correlation	.436**	.419**	.389**	.389**	.431**	1.000	.358**
	p-value	0.000	0.000	0.000	0.000	0.000		0.000
Q9.29	Correlation	.526**	.601**	.535**	.539**	.556**	.358**	1.000
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.18 it can be seen that all the items loading onto the third component are positively correlated and they are all significantly correlated at a 1% level of significance.

Table 4.19: Correlations for Component number 4 of the EFA

		Q9.21	Q9.22	Q9.24	Q9.25	Q9.26	Q9.27	Q9.28
Q9.21	Correlation	1.000	.721**	.653**	.588**	.562**	.654**	.634**
	p-value		0.000	0.000	0.000	0.000	0.000	0.000
Q9.22	Correlation	.721**	1.000	.754**	.595**	.622**	.714**	.661**
	p-value	0.000		0.000	0.000	0.000	0.000	0.000
Q9.24	Correlation	.653**	.754**	1.000	.650**	.698**	.721**	.673**
	p-value	0.000	0.000		0.000	0.000	0.000	0.000
Q9.25	Correlation	.588**	.595**	.650**	1.000	.634**	.589**	.558**
	p-value	0.000	0.000	0.000		0.000	0.000	0.000
Q9.26	Correlation	.562**	.622**	.698**	.634**	1.000	.783**	.643**
	p-value	0.000	0.000	0.000	0.000		0.000	0.000
Q9.27	Correlation	.654**	.714**	.721**	.589**	.783**	1.000	.796**
	p-value	0.000	0.000	0.000	0.000	0.000		0.000
Q9.28	Correlation	.634**	.661**	.673**	.558**	.643**	.796**	1.000
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.19 it can be seen that all the items loading onto the fourth component are positively correlated and they are all significantly correlated at a 1% level of significance.

4.5.3.1.2.2 Discriminant validity

Now that convergent validity has been shown in the previous section, Spearman correlations coefficients are calculated and interpreted for discriminant validity. As previously mentioned, for discriminant validity, items that do not load onto the same factors should have lower correlations than those loading onto the same factors. Since we have 29 questions (Questions 9.1 to 9.29) and a 29 x 29 correlation matrix would not fit onto one page, only one correlation is discussed here for illustration purposes. Although only one correlation between items loading onto different factors is discussed here for illustration purposes, it should be noted that the researcher checked all the correlations between items loading onto different factors for discriminant validity. Consider Question 9.16 which loaded onto Component 3 and Question 9.26 which loaded onto Component 4. Although the correlation is significant at a 1% level of significance (p-value = 0.000), the correlation is weak positive (r = 0.283). Question 9.16 has higher correlations with the questions loading on Component 3 and Question 9.26 has higher correlations with those loading on Component 4, which is desirable.

4.5.4 Measurement Model (Confirmatory Factor Analysis)

A Confirmatory Factor Analysis (CFA) using AMOS was done. A CFA is conducted to confirm whether a theoretical structure can be supported and is a necessary step to be taken prior to developing the structural model. CFA involves specification and estimation of one or more hypothesised factor structure(s), each of which proposes a set of latent variables to account for covariance among a set of observed variables. If the CFA does not get the appropriate fit, then by deleting inappropriate questions or by amending the modification indices (M.I.), one can enhance the fitness level (Pai & Tu, 2011).

It is important to note the difference between observed and latent variables. According to Kline (2012) the observed variables are those that were captured using the data collection instrument whilst latent factors are factors that cannot be captured directly, but instead, we use observed variables to reflect them. For instance, items related to a construct are considered observed variables while the construct itself is referred to as a latent variable or construct. When evaluating the measurement model, there are a number of goodness-of-fit (GOF) indices that can be used to measure how well the actual data collected (observed variables) matches the estimated covariance matrices (theoretical data) (Byrne, 2010). There are a number of various indices used in the structural equation modelling literature each with varying acceptable thresholds. In this study, the author relied on a number of model-fit indices and their thresholds, as discussed by (Hair et al., 2010).

4.5.4.1 Initial CFA for the complete theoretical model

Using the items proposed from the literature review, the following initial CFA model (Figure 4.6) was created with SPSS AMOS software. The oval shaped items on the right represent the various factors (see Table 4.20) also known as latent variables or unobserved variables. Each factor is represented by a number of measured variables or indicators designated by a box. These measured variables were captured in the questionnaire used by this study. Lastly, each measured variable has an error variance that is estimated by the software package. In this section, only the model and corresponding summary statistics are presented. The reader is referred to Annexure F in Section 7.3 for the complete AMOS output of the CFA for the complete theoretical model.

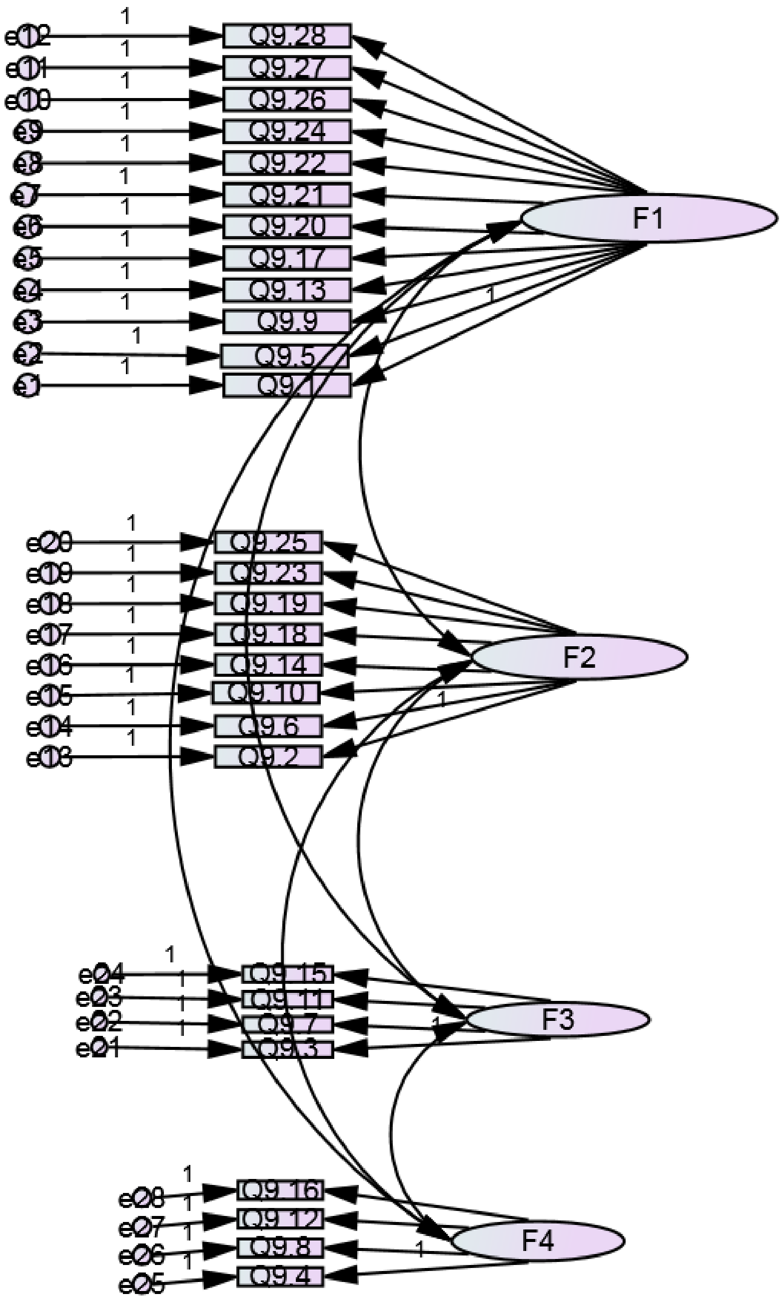

Figure 4.6: CFA for the complete theoretical model

Table 4.20: Summary of the statistics of the complete theoretical model

Factor	Label	Items
1	Performance Expectancy	Twelve items: 9.1, 9.5, 9.9, 9.13, 9.17, 9.20, 9.21, 9.22, 9.24, 9.26, 9.27, 9.28
2	Effort Expectancy	Eight items: 9.2, 9.6, 9.10, 9.14, 9.18, 9.19, 9.23, 9.25
3	Social Influences	Four items 9.3, 9.7, 9.11, 9.15
4	Facilitating condition	Four items 9.4, 9.8, 9.12, 9.16

The model fit summary is presented in Table 4.21.

Table 4.21: Summary of the statistics of the complete theoretical model

Statistic	Acceptable level	Value for the complete theoretical model
Normed Chi-square (CMIN/DF)	Between 1 and 2	4.343 - unacceptable
p-value of the Chi-square test statistic	p-value > 0.05	0.001 - unacceptable
Root mean-square error of approximations (RMSEA)	RMSEA < 0.08	0.133 - unacceptable
Goodness-of-fit index (GFI)	GFI > 0.80	0.648 - unacceptable
Comparative fit index (CFI)	CFI > 0.90	0.793 - unacceptable

For the first proposed model, there was an unacceptable level of model fit for the measurement mode. According to Hu and Bentler (1999) and Kline (2012), the goodness of fit index (GFI) should exceed 0.8, the comparative fit index (CFI) should exceed 0.9 and root mean square error of approximation (RMSEA) should not exceed 0.08. Furthermore, the Normed Chi-square (CMIN/DF) should be between 1 and 2 and the p-value of the Chi-square test statistic should be greater than 0.05.

All the model-fit indices were below their respective common acceptable levels suggested by previous research. Table 4.21 provides a summary of the statistics of the theoretical model. Based on the recommendations put forward by Hair et al. (2010), there are a number of steps that can be taken to improve GOF. Firstly, factors with low loadings can be dropped (Hair et al., 2010). The researcher therefore, dropped all items that were loading lowly from the model. In order to find the items that were loading poorly, the standardised regression weights in the AMOS output were investigated. The standardised regression weights, also known as factor loadings, are given in Annexure F and all items with loadings less than 0.7 were deleted. Ideally, each factor should have a minimum of three items although if some constructs had less than three it would still be acceptable (Iacobucci, 2010). This process was repeated several times until the acceptable model fit (discussed below) was reached.

4.5.4.2 Improved CFA

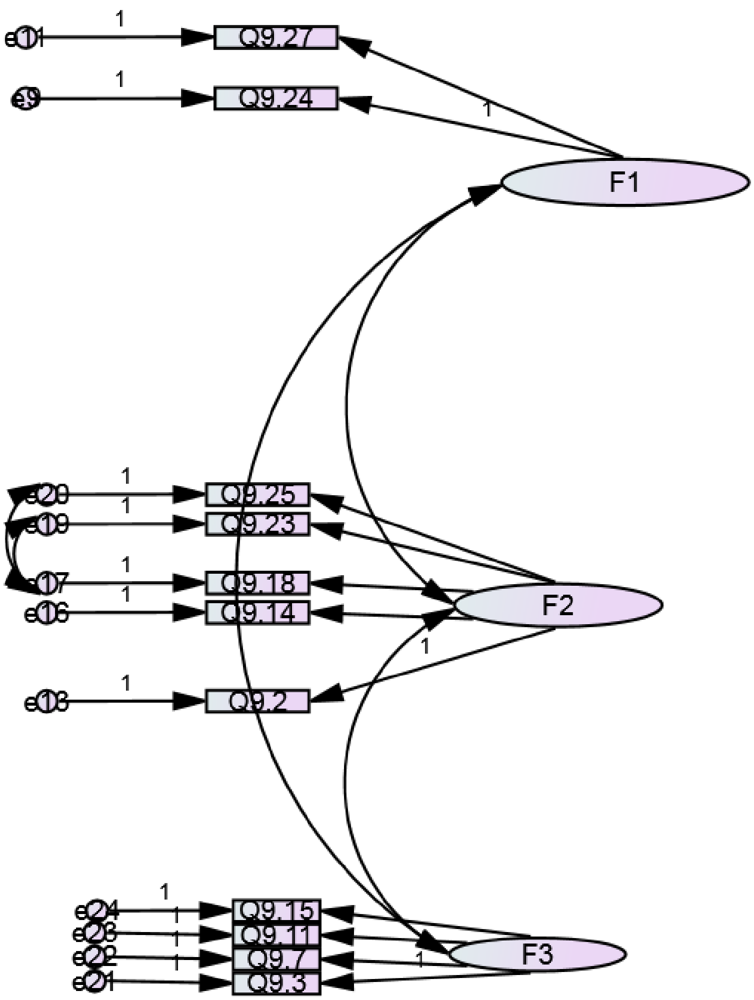

Figure 4.7: CFA for the acceptable theoretical model

Table 4.22: Summary of the statistics of the acceptable model

Statistic	Acceptable level	Value for the complete theoretical model
Normed Chi-square (CMIN/DF)	Between 1 and 2	1.865
p-value of the Chi-square test statistic	p-value > 0.05	0.103
Root mean-square error of approximations (RMSEA)	RMSEA < 0.08	0.067
Goodness-of-fit index (GFI)	GFI > 0.90	0.936
Comparative fit index (CFI)	CFI > 0.90	0.982

As can be seen from the model fit summary above (Table 4.22), the GOF indices indicate that the model is better than the previous one. GOF indices indicate the degree to which the data fit the proposed model, and in this case and in comparison, to the previous model, GOF indices are indicating that this model is fitting the data very well. It can be noted that from the model above there is in fact only three factors (and not four with only having two items loading meaningfully onto Factor 1, five items onto Factor 2 and four items onto Factor 3.

4.5.4.3 Reliability and Validity of new improved model

Investigating the reliability and validity of the proposed model is important when doing a confirmatory factor analysis (CFA), particularly since changes (e.g. addition and removal of items) were introduced to the model. High reliability is argued to be associated with lower measurement errors (Hair et al., 2010). Additionally, to reflect latent factors properly, observed variables need to show evidence of reliability and validity (Schumacker & Lomax, 2010).

4.5.4.4 Reliability

Cronbach’s alpha values for the three remaining construct items were investigated after changes were made to the purposed CFA model. Table 4.23 shows that the remaining three constructs of the final CFA model had Cronbach's alpha values well above the cut-off point of 0.7 (Osborne & Waters 2002, Tavakol & Dennick 2011).

Table 4.23: Cronbach Alpha values for the confirmatory factor analysis

Factor number from Figure 4.6	Question number	Cronbach Alpha
1	9.24, 9.27	0.864
2	9.2, 9.14, 9.18, 9.23, 9.25	0.931
3	9.3, 9.7, 9.11, 9.15	0.929

4.5.4.5 Validity

Construct validity was once again investigated after significant changes to the proposed CFA model was made (Trochim, 2006a). As mentioned in Section 4.5.3.1, for convergent validity Spearman correlation coefficients between items loading on the same factors should be high and for discriminant validity the correlations between items loading onto different factors should be lower than the correlations presented for convergent validity. Firstly, convergent validity is considered, followed by a discussion on the discriminant validity of the CFA.

4.5.4.5.1 Convergent Validity

Table 4.24: Correlations for Factor number 1 of the CFA

		Q9.24	Q9.27
Q9.24	Correlation	1.000	.721**
	p-value		0.000
Q9.27	Correlation	.721**	1.000
	p-value	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.24 it can be seen that all the items loading onto the first factor are positively correlated and they are all significantly correlated at a 1% level of significance.

Table 4.25: Correlations for Factor number 2 of the CFA

		Q9.2	Q9.14	Q9.18	Q9.23	Q9.25
Q9.2	Correlation	1.000	.686**	.679**	.634**	.657**
	p-value		0.000	0.000	0.000	0.000
Q9.14	Correlation	.686**	1.000	.720**	.726**	.721**
	p-value	0.000		0.000	0.000	0.000
Q9.18	Correlation	.679**	.720**	1.000	.676**	.642**
	p-value	0.000	0.000		0.000	0.000
Q9.23	Correlation	.634**	.726**	.676**	1.000	.716**
	p-value	0.000	0.000	0.000		0.000
Q9.25	Correlation	.657**	.721**	.642**	.716**	1.000
	p-value	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.25 it can be seen that all the items loading onto the second factor are positively correlated and they are all significantly correlated at a 1% level of significance.

Table 4.26: Correlations for Factor number 3 of the CFA

		Q9.3	Q9.7	Q9.11	Q9.15
Q9.3	Correlation	1.000	.720**	.736**	.736**
	p-value		0.000	0.000	0.000
Q9.7	Correlation	.720**	1.000	.814**	.782**
	p-value	0.000		0.000	0.000
Q9.11	Correlation	.736**	.814**	1.000	.730**
	p-value	0.000	0.000		0.000
Q9.15	Correlation	.736**	.782**	.730**	1.000
	p-value	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed)

From Table 4.26 it can be seen that all the items loading onto the second factor are positively correlated and they are all significantly correlated at a 1% level of significance.

4.5.4.5.2 Discriminant Validity

Similar to Section 4.5.3.1.2.2, it is impractical to place a 29 x 29 correlation matrix into this section and discuss each correlation. Instead, only one correlation is discussed here for illustration purposes. Although only one correlation between items loading onto different factors is discussed here for illustration purposes, it should be noted that the researcher checked all the correlations between items loading onto different factors for discriminant validity. Consider Question 9.2 which loaded onto Factor 2 and Question 9.7 which loaded onto Factor 3. Although the correlation is significant at a 1% level of significance (p-value = 0.000), the correlation is weak positive (r = 0.373). Question 9.2 has higher correlations with the questions loading on Factor 2 and Question 9.7 has higher correlations with those loading on Factor 3, which is desirable.

Since the measurement model has proven to be reliable and valid, the next step was to develop the structural model, to investigate the various paths and test the hypotheses.

4.5.5 Structural Model

Structural Equation Modelling (SEM) is an analysis approach that uses models to explain relationships between multiple variables while at the same time allowing researchers to use latent factors to represent some concepts more accurately (Hair et al., 2010).

This study used the available literature to identify and develop a conceptual model (Chapter 2) to be considered as the base mode that was analysed and tested using SEM. In the previous chapter, an EFA was run to identify underlying relationships between the various constructs. That structure was then converted into a measurement model, to assess the reliability and validity of the measures. After concluding that the measurement model developed in the previous chapters was valid, in this chapter, the measurement model was converted into a hybrid model (measurement and structural model combined) to test the various hypotheses and confirm or explore any possible moderation effects. Applications and steps taken by the researcher were guided by the work of Byrne (2010), Hair et al. (2010) and Kline (2012), and as key figures in this area.

4.5.5.1 Base Model

From the CFA it was found that the factor 'facilitating conditions' were dropped from the model. The UTAUT model in Figure 2.4 was amended and the testing of this amended model was done using structural equation modelling. The amendments to figure 2.4 included the following; of the four constructs of the UTAUT model, only three remained after the CFA, namely, PE, EE and SI. Structural equation modelling provides a basis for hypothesis testing and the hypotheses are as follows:

Hypothesis 1:
H_0: Performance expectancy (PE) has no significant effect on behavioural intention (BI).
H_a: Performance expectancy (PE) has a significant effect on behavioural intention (BI).

Hypothesis 2:
H_0: Effort expectancy (EE) has a no significant effect on behavioural intention (BI).
H_a: Effort expectancy (EE) has a significant effect on behavioural intention (BI).

Hypothesis 3:
H_0: Social influence (SI) has no significant effect on behavioural intention (BI).
H_a: Social influence (SI) has a significant effect on behavioural intention (BI).

Hypothesis 4:
H_0: Behavioural intention (BI) has no significant effect on the actual use (USE).
H_a: Behavioural intention (BI) has a significant effect on the actual use (USE).

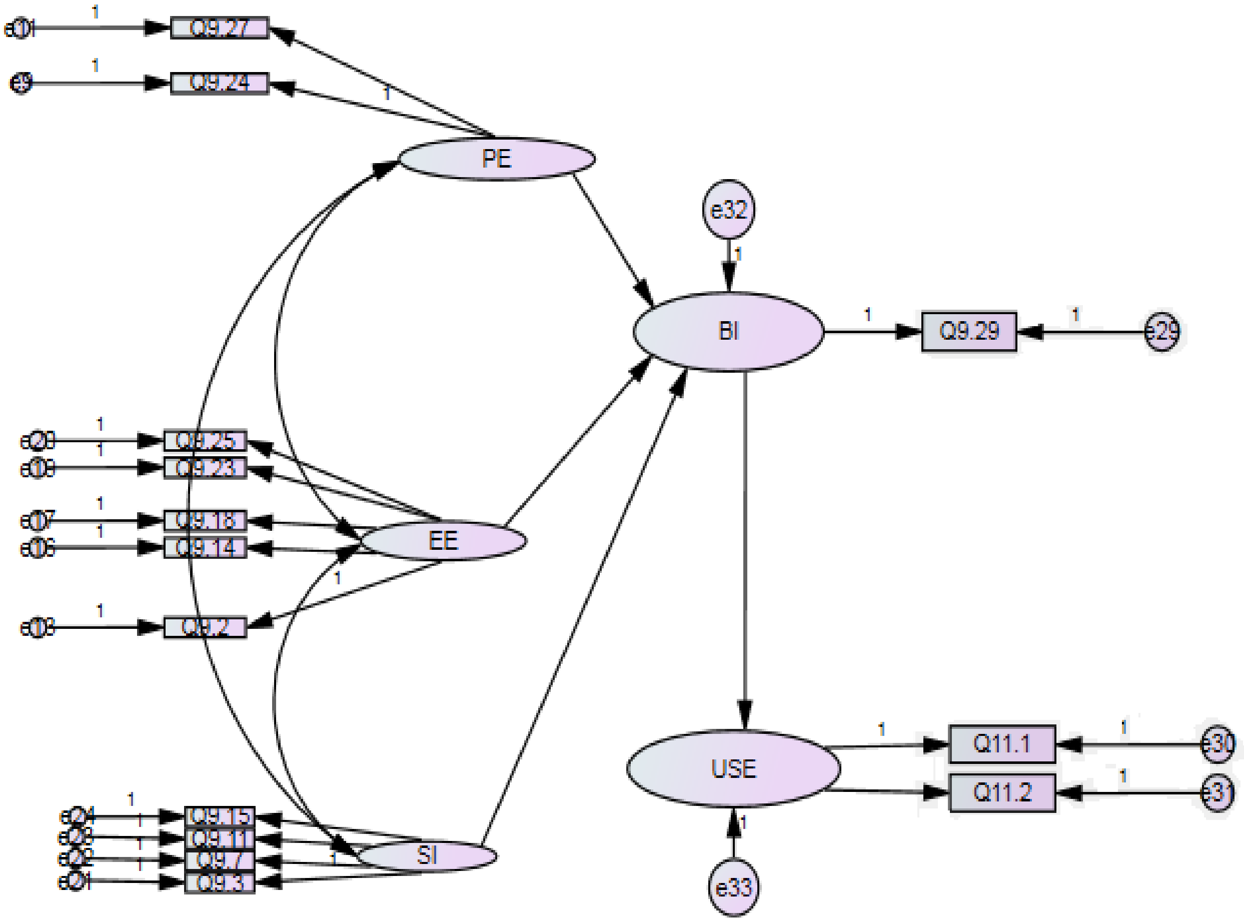

Figure 4.8: Structural equation model

Table 4.27: Summary of the statistics of the Structural equation modelling model

Statistic	Acceptable level	Value for the complete theoretical model
Normed Chi-square (CMIN/DF)	Between 1 and 2	1.547 - acceptable
p-value of the Chi-square test statistic	p-value > 0.05	0.241 - acceptable
Root mean-square error of approximations (RMSEA)	RMSEA < 0.08	0.054 - acceptable
Goodness-of-fit index (GFI)	GFI > 0.80	0.925 - acceptable
Comparative fit index (CFI)	CFI > 0.90	0.984 - acceptable

Table 4.28: Structural equation modelling results

Path (hypothesis)	t-test	p-value	Hypothesis testing result
PE → BI (Hypothesis 1)	2.302	0.021	H_0 rejected, PE has an effect on BI.
EE → BI (Hypothesis 2)	1.466	0.143	H_0 not rejected, EE has no effect on BI.
SI → BI (Hypothesis 3)	4.351	< 0.001	H_0 rejected, SI has an effect on BI.
BI → USE (Hypothesis 4)	7.162	< 0.001	H_0 rejected, BI has an effect on actual USE.

From Table 4.28 it can be seen that three of the four paths were statistically significant. The findings reveal that the performance expectancy (PE) construct positively predicted the behavioural intention (BI) construct ($t = 2.302$, p-value = 0.021), therefore, H_a was supported. This finding concurs with multiple studies in the literature that also examined the effect of performance expectancy on behavioural intention (Moran, Hawkes & El-Gayar, 2010; Wang & Shih, 2009; Wong, Russo & McDowall, 2013; Wong, Teo & Goh, 2015). Secondly, effort expectancy did not significantly predict the BI construct ($t = 1.466$, p-value = 0.143). Within the body of literature available on the UTAUT there are different findings with regard to the influences of effort expectancy (EE). Some studies show that EE has no influence on behavioural intention (BI) (Jong & Wang, 2009; Park, 2009; Šumak, Polancic & Hericko, 2010; Venkatesh et al., 2003) while others indicate that a significant influence does exist as is the case in this study (Boontarig, Chutimaskul, Chongsuphajaisiddh, & Papasratorn, 2012; El-Gayar & Moran, 2006; Martins & Kellermanns, 2004; Oye, A.Iahad & Ab.Rahim, 2012; Yamin & Lee, 2010).

For the third hypothesis, it was found that the social influence (SI) construct positively predicted the behavioural intention (BI) construct ($t = 4.351$, p-value < 0.001). This is in accordance with the results of various studies in the literature (Moran et al., 2010; Teo, 2011; Venkatesh & Davis, 2000; Venkatesh et al., 2003; Wang & Shih, 2009). Lastly, the SEM indicated that the behavioural intention (BI) construct positively predicted the actual use behaviour (USE) construct (t = 7.162, p-value < 0.001). This finding concurs with the results from similar studies in literature (Meng & Wang, 2012; Moran et al., 2010; Wang & Shih, 2009). It is noteworthy that three out the four relationships were supported.

The effects of moderators are discussed next. The UTAUT model has moderators such as age and gender (see Section 2.6.1.6). It is important to point out that Alshehri (2013) noted that "… no relationships were expected to completely reverse due to moderation and it was expected that any robust relationship between the latent and variables would show, even when moderated" (Alshehri, 2013, p. 140). Mossholder, Kemery and Bedeian (1990) stated that even if moderator effects are found, interpretation is extremely complex as even the sign of the standardised regression coefficient of the moderator may not indicate anything. Because of the reasons listed here and the fact that our initial research questions did not include a question on how the UTAUT moderators (for example, age and gender) influence use behaviour (USE), this is not investigated further here. The aim of this study was not to see, for example, whether females made more use of ICTs in classroom than males.

4.6 CHAPTER SUMMARY

Chapter 4 discussed the responses from participating teachers. Section A of the questionnaire captured the demographic information as well as some background questions such as age, gender and years' teaching experience etc. Section B, of the questionnaire focused on the integration of ICTs in teaching and learning. The top ten ICTs available to participating teachers were identified and include, in order: Personal Computer/Laptop, Microsoft Word, E-Mail, Printer, The Internet, Microsoft PowerPoint, Microsoft Excel, Data Projector, Scanner and YouTube Videos. For a detailed discussion please refer to Section 4.3. How these ICTs were utilised within the educational domain was also discussed along the SAMR integration model captured in Section D of the questionnaire. Content analyses indicated that the substitution category was by far the largest of the four with the vast majority of entries (71.70%) falling within this category. A further 23.90% were integrating ICTs at the Augmentation level, whilst only three cases (1.89%) could be linked to the modification category. For the redefinition category, no evidence could be found that participating teachers were functioning at this level. See Section 4.4 for a discussion on the integration according to the SAMR model.

Section C of the questionnaire focussed on identifying the factors as to why teachers integrate ICT into the teaching and learning of mathematics. The four constructs of the UTAUT framework (Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions) were hypothesised to influence teachers' use of ICTs within the educational domain. The researcher believed that these four constructs (factors) could explain why teachers integrate ICT into their teaching practices. An EFA was done on Section C in order to check whether or not there were indeed four factors. The researcher believed that behavioural intention, was not a deciding factor as to why teachers integrate ICT. Thus, it was envisaged that this construct should not load highly onto any of the factors. This observation was confirmed by the EFA which indicated that there were indeed four factors. Factor 1 (Performance Expectancy) explains 58.3% of the total variance, Factor 2 (Effort Expectancy) explained 6%, Factor 3 (Social Influences) explained 4.4% and Factor 4 (Facilitating Conditions) accounted for 3.8%, respectively. It was also observed that questions 9.4, 9.8, 9.12 and 9.16 which the researcher thought would load onto the same factor *facilitating condition*, did not. To investigate this further a CFA was done.

For the first proposed measurement model, there was an unacceptable level of model fit. Indicated by all the model-fit indices being below their respective common acceptable levels suggested by the previous research. See Table 4.21 for a summary of the statistics of the purposed theoretical model. The researcher dropped all items that were loading lowly from the model by investigating the standardised regression weights in the AMOS output (Hair et al., 2010). All items with loadings less than 0.7 were deleted, see Annexure F for a full list of factor loadings. This process was repeated several times until the acceptable model fit was reached. The final acceptable model however indicated that there were in fact only three factors (and not four) as envisaged by the first model. In the final acceptable model, only two items were loading meaningfully onto Factor 1, five items onto Factor 2 and four items onto Factor 3 (see Figure 4.8).

Finally, from the CFA it was gathered that the factor 'facilitating conditions' should be dropped from the model. The UTAUT model in Figure 2.4 was amended and the testing of this amended model was done using structural equation modeling. Informed by the literature, the EFA and the CFA, four hypotheses were made and they were:

1) Performance expectancy (PE) has no effect on behavioural intention (BI)

2) Effort expectancy (EE) has no effect on behavioural intention (BI)

3) Social influence (SI) has no effect on behavioural intention (BI)

4) Behavioural intention (BI) has no effect on the use (USE).

The SEM indicated that three of the four paths were statistically significant (see Section 4.5.5.1). The findings reveal that: 1) the performance expectancy (PE) construct positively predicted the behavioural intention (BI) construct; 2) effort expectancy did not significantly predict the BI construct; 3) social influence (SI) construct positively predicted the behavioural intention (BI) construct and lastly, the BI construct positively predicted the use behaviour (USE) construct.

5. CHAPTER 5: DISCUSSION

The Gauteng Department of Education (GDE) has invested over R-800 million in e-learning in the 2015/16 financial year with a projected R-2 billion over the 2015 Medium Term Expenditure Framework (MTEF) period (GDE, 2015). However, according to the ‘Action plan 2019’ document, published by the National Department of Education, there is still a major weakness in the system when it comes to the implementation of ICT to improve the teaching and learning process (DBE, 2015). The document also states that “a big concern is the little research available on how ICTs are currently employed in schools”. This study set out to explore what factors influence mathematics teachers’ integration of ICT into the teaching and learning environment. Thereby, the study aims to help add to the limited research available as stated in the ‘Action plan 2019’ document and also focuses specifically on mathematics as the quality of mathematics education is at the lower end of the spectrum (Reddy et al., 2012; Reddy et al., 2016). With this in mind, three secondary research questions were formulated and they included: 1) What available ICTs are being integrated by mathematics teachers? 2) How are the ICTs being integrated in the teaching and learning process? 3) Why are mathematics teachers integrating ICTs in their classrooms? From the literature review a conceptual framework for the study was developed. This framework included a combination of an amended version of Venkatesh et al., (2003) UTAUT framework and Puentedura’s (2006) SAMR-model (see Section 2.6). In this chapter, the findings of this study are summarised along with the secondary research questions stated above, conclusions are drawn and the implications of the study are suggested.

5.1 Discussion of the secondary research questions

5.1.1 What available ICTs are being integrated by mathematics teachers?

To better understand what factors influence the integration of ICT by mathematics teachers, the researcher set out to first identify what ICTs are available and used by participating teachers. Participants were asked to select with a “yes” or “no” from a predetermined list what ICTs are available and used by them. The top ten in order were: 1) Personal Computer/Laptop; 2) Microsoft Word; 3) E-Mail; 4) Printer; 5) The Internet; 6) Microsoft PowerPoint; 7) Microsoft Excel; 8) Data Projector; 9) Scanner; 10) YouTube Videos. Identifying what ICTs are available to teachers is indicative of how and why they would integrate ICT into their classrooms. How each of these ICTs are integrated within the educational domain will, however, be discussed in the next section. The emphasis is to identify what ICTs are available and used by teachers. We can divide the ICTs into three categories, namely hardware, software and internet related resources.

As expected the hardware includes a PC or laptop, printer, data projector and a scanner. These findings correlate with a recent report from the Clayton Christensen Institute who also found that the most frequently used hardware by South African teachers was a laptop accounting for (30.3%) (Fisher, Bushko & White, 2017). What is however surprising is the fact that mobile devices do not feature in the top ten list. In this study, mobile devices such as cell phones and tablets are listed at number fourteen on the full list, with 73% of participating teachers indicating that it is available to them for the use in the teaching and learning of mathematics (see Annexure D). In contrast, the Clayton Christensen Institute report found that, within education, mobile devices (combining cell phones and tablets) accounted for a total of 49.5%, the biggest category if combined (Fisher et al., 2017). It could however be perceived that in this study participating teachers might classify the use of the internet, email and YouTube videos as part of mobile technology as these are often accessed on mobile devices. In the same manner, the use of software and internet related resources require a personal computer or laptop or a cell phone. Hence, the personal computer/Laptop is the number one available ICT used by teachers.

On the software side, it is with no surprise, that the most popular software is the Microsoft Office Suite: Word, PowerPoint, and Excel. This finding is confirmed by the literature as research has shown the software mostly used for integration was word processing (Buabeng-Andoh, 2012; Fisher et al., 2017; Stols et al., 2015). The internet related resources are email and YouTube Videos. Interesting to the researcher was the use of video streaming services such as YouTube is among the top ten list, especially for the teaching and learning of mathematics. This is indicative of the fact that the majority of teachers are aware and/ or use video content within their teaching practises. A 2015 survey by United Sates based company, Kaltura, into the use of video in education states that

> Video is transforming the way we teach, learn, study, communicate, and work within educational institutions. Harnessing the power of video to achieve improved outcomes such as better grade in exams or more effective knowledge transfer, is becoming an essential skill. (Kaltura, 2015 p.1)

The report also found that on average ten videos a month were being watched by students in United States and 91% of the respondents believed that from their experiences video improves learning (Kaltura, 2015). A literature search on Google scholar could not provide any evidence or research of video being utilised specifically in mathematics classrooms in South Africa. This study therefore adds to the current pool of research and recommends that the use of video within our mathematics classrooms should be further investigated. Taking the TIMSS results into consideration, the use of video could potentially lead to a better solution for improving the poor state of mathematics education in the country (Reddy et al., 2012; Reddy et al., 2016).

5.1.2 How are the ICTs being integrated in the teaching and learning process?

To explore how teacher integrated ICT into their classrooms, the researcher broke the question up into two parts with the first part divided into three sub-categories.

5.1.2.1 Part One

In each category of part one, participating teachers indicated on a 4-point Likert scale 1) what ICTs were utilised for the teaching and learning of mathematics in the classroom, 2) what ICTs were utilised for the preparation and 3) what ICTs were utilised for personal development. The top ten of each category were identified in order (see Table 5.1).

Table 5.1: Summary of the top 10 identified ICTs in order

Spot	ICTs used most often in class for teaching	ICTs used most often for preparation	ICTs most often used for personal development
1	Personal Computer/Laptop	Personal Computer/Laptop	Personal Computer/Laptop
2	Data Projector	Microsoft Word	The Internet
3	Microsoft Word	Printer	Microsoft Word
4	Microsoft PowerPoint	The Internet	Microsoft Excel
5	Printer	Microsoft Excel	Printer
6	Interactive Board	Microsoft PowerPoint	Email
7	The Internet	Scanner	YouTube Videos
8	Microsoft Excel	YouTube Videos	Microsoft PowerPoint
9	YouTube Videos	Data Projector	Mobile Devices
10	Dynamic Mathematics Software	Dynamic Mathematics Software	Dynamic Mathematics Software

It is noticeable how the positioning of the top ten ICTs shift up and down each category, in terms of priority. All the ICTs are mostly similar on each list, with the exception of the interactive whiteboard appearing on the in “class for teaching” list, the scanner appearing on the “for preparation” list and mobile devices appearing on the “professional development” list. Several observations can be deducted from Table 5.1 and the researcher will discuss some next.

Research shows that increased availability of visual images in mathematics education is critical, since ‘visualisation’ plays a key part in mathematical understanding (Arcavi, 2003; Sedig & Liang, 2006; Sedig & Sumner, 2006). This is confirmed by the results of this study where ICTs such as the data projector, PowerPoint, the interactive board and dynamic mathematics software all featuring in teaching and learning category. A second observation relates to the preparation done by the participating teachers. Firstly, with Microsoft Word and a printer in second and third place on the “for preparation” list, the researcher concludes that teachers create a great deal of additional resources to be used for the teaching and learning of mathematics. Secondly, adding to this is the addition of the internet in fourth place on the “for preparation” list indicating that teachers are actively searching for improved and valuable teaching resources to be used in their lessons. This emphasises the importance of online mathematics projects such as the Mathematics Information and Distribution Hub (MIDHub) for South African mathematics teachers (Stols et al., 2015).

What the reseacher wishes to point out here is that it is preceived by looking at the ICTs that the teachers in this sample do a great deal of additional planning and finding of quality supplementary resources. This could be indicative of the skewness of the sample for the study as it was reported that 68.06% of the teachers were from city schools where education is generally perceived to be better. Furthermore, a total of 66.50% of the participating teachers were from two of the top performing provinces in the country namely Gauteng and Western Cape provinces. Teachers in this sample could therefore feel more responsible for their teaching and hence reverted to ICTs to help improve and inform their pedagogies. As in the words of Barber and Mourshed (2007 p. 16), “the quality of an education system cannot exceed the quality of its teachers, and the only way to improve outcomes is to improve instruction.” The addition of email and mobile devices on the professional development list indicate the powerful role that ICTs can play in improving teachers’ content and pedagogical knowledge. Therefore, the researcher suggests that further research be done into how teachers from these top performing provinces are utilising ICTs effectively so that it could be encouraged in other provinces to help improve mathematics education in South Africa.

5.1.2.2 Part Two

In the second part, participating teachers were asked to list the ICT that they felt had the biggest impact on the teaching and learning of mathematics. This was an open-ended question and responses often included more than one specific ICT. The ICT perceived by participating teachers to have the biggest impact on the teaching and learning of mathematics was a data projector with 19.42% of the responses. The fact that a data projector can be used in combination with a multitude of ICTs such as a personal computer, laptop, mobile device or interactive board could be a possible explanation as to why many teachers see it as the number one ICT. Second in line was Dynamic Mathematics Software such as GeoGebra, Desmos and Autograph with 19.06% of the responses and the interactive whiteboards were third with 16.55% of the responses. To gain a deeper understanding of why participating teachers chose a specific ICT they were also asked to elaborate on how they used the particular ICT in their daily teaching and learning of mathematics.

The participating teachers' responses were coded using the SAMR model. Content analyses indicated that the substitution category was by far the largest of the four with the vast majority of entries (71.70%) falling within this category. A further 23.90% were integrating ICTs at the Augmentation level, whilst only three cases (1.89%) could be linked to the modification category. For the redefinition category, no evidence could be found that participating teachers were functioning at this level (see Section 4.4.). According Nkonki & Ntlabathi (2016), in the substitution category, technology acts as a direct tool, a substitute, with no functional change in the teaching and learning practices. This result links directly to the top three ICTs mentioned in part one. A logical conclusion that the researcher draws from the data presented could that teachers are of the opinion that ICTs can only be used as a visual aid within the classroom environment.

5.1.3 Why are mathematics teachers integrating ICTs in their classrooms?

The final part of the research focused on understanding why teachers integrate ICTs. The UTAUT model was selected to accomplish this. The four constructs of the UTAUT framework (Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions) were hypothesised to influence teachers' use of ICTs within the educational domain. The researcher believed that these four constructs (factors) could explain why teachers integrate ICT into their teaching practices. An EFA and CFA were done in order to check whether or not there were indeed four factors (see Section 4.5). Informed by the literature, the EFA and the CFA, four hypotheses were made and tested using SEM. The outcome of each individual hypothesis will be discussed below.

5.1.3.1 Hypothesis 1

The findings reveal that the performance expectancy (PE) construct positively predicted the behavioural intention (BI) construct ($t = 2.302$, p-value = 0.021). The positive effect of performance expectancy indicates that teachers believe that the use of ICT improves the teaching performance. Furthermore, in accordance with the literature, since performance expectancy affects behavioural intention and effort expectancy could not be correlated to predict behavioural intention (Meng & Wang, 2012; Wong et al., 2013), it can be said that teachers use ICT because of its positive effects on teaching performance rather than its ease of use. This is explained in more depth next.

5.1.3.2 Hypothesis 2

Secondly, Effort expectancy did not significantly predict the BI construct ($t = 1.466$, p-value = 0.143). With effort expectancy not significantly predicting intentional use of ICT, it could be translated as teachers not necessarily using ICT because it is easier or more difficult to learn and use. Furthermore, this might also be linked to the fact that facilitating conditions were not seen as a predicting factor of intentional use of ICT. With ICT becoming more obligatory and available in educational institutions as well as easier to use, it could be that teachers have learned a coping mechanism to resolve difficulties and problems linked to the use of software and hardware and do not see this as a predicting factor.

5.1.3.3 Hypothesis 3

For the third hypothesis, it was found that the social influence (SI) construct positively predicted the behavioural intention (BI) construct ($t = 4.351$, p-value < 0.001). The strong positive effect of social influence is the result that the use of

ICT was deemed necessary by the people who were important for the participating teachers, as also suggested in other literature (Moran et al., 2010; Teo, 2011). With this result social influence might be used as an advantage by school leadership and governments, in creating usage intention towards ICT. If teachers who adopt and use ICT are increased to a significant level, the participation of the other non-adopting teachers might increase quicker. Researchers could explore ways to increase teachers' acceptance and use of ICT.

5.1.3.4 Hypothesis 4

Finally, the findings revealed that the behavioural intention (BI) construct positively predicted the actual use behaviour (USE) construct ($t = 7.162$, p-value < 0.001). It could therefore be stated with 99% level of confidence ($p < 0,001$) that teachers' intention to use ICT does in fact predict the actual use of ICT for teaching and learning of mathematics, thereby confirming the finding of Venkatesh et al. (2003). The positive effect of BI on the use of ICT could also further be interpreted as meaning that the use of ICT in the future would be more readily adopted if Performance Expectancy and Social Influences were present.

5.1.4 Concluding remarks

This study found the top ten ICTs available and accessible to participating teachers to be: 1) Personal Computer/Laptop; 2) Microsoft Word; 3) E-Mail; 4) Printer; 5) The Internet; 6) Microsoft PowerPoint; 7) Microsoft Excel; 8) Data Projector; 9) Scanner; 10) YouTube Videos. Identifying what ICTs are available to teachers is indicative of how and why they would integrate it into their classrooms. Therefore, how each of these ICTs were being used by the participating teachers were explored and captured in Table 5.1. Further analysis and classification using Puentedura's, (2006) SAMR model revealed that the substitution category was by far the largest of the four categories with 71.70% of participating teachers falling within this category. A further 23.90% were integrating ICTs at the Augmentation level, whilst only three cases (1.89%) could be linked to the modification category. For the redefinition category, no evidence could be found that participating teachers were functioning at this level (see Section 4.4). Why teachers integrate

ICT was explored using Venkatesh et al.'s (2003) UTAUT framework. After several statistical analyses Performance Expectancy and Social Influence were the only two constructs that significantly predicted if participating teachers intended to utilise ICT in their classroom or not. This study could therefore not confirm Venkatesh et al.'s (2003) hypothesis that Effort Expectancy and Facilitating Conditions would predict participating teacher's intention to use ICT. Venkatesh et al.'s (2003) also hypothesised that users' intentional use of ICT predicts their actual use of ICT and this was confirmed by the study.

5.1.5 Limitations

As with many research studies, this study has some limitations. The researcher mentioned previously that data was collected by purposeful sampling, but because of the nature of the topic being the integration of ICT, participating teachers came predominantly from city schools where ICTs are readily available especially in the two provinces namely Gauteng and the Western Cape. These two provinces both have intensive focus on ICT with various ICT implementation plans. The findings of this study therefore, do not necessarily represent the whole population of in-service mathematics teachers in South Africa, especially with the sample size only being 191 mathematics teachers. Secondly, the actual use of ICT was measured using a self-reported questionnaire, a better approach would have been a longitudinal study encompassing not only survey research but also different data gathering strategies such as interviews and in class observations. This could inform the research questions in a broader sense but because of time constraints and the scope of this master dissertation, this was not possible.

5.1.6 Implications of the study

The findings from this study have important implications for the integration of ICT in the teaching and learning of mathematics in South Africa. Findings revealed that the personal computer/ laptop and the data projector were two of the main ICTs used in schools for the teaching and learning of mathematics. Related to this, it was further found that most mathematics teachers, who participated in this study, used ICTs as a direct substitution tool for old traditional teaching method, without any functional changes to pedagogy. It is therefore important to point out that if mathematics education is to be improved, professional development programmes should focus on training teachers to make fundamental pedagogical shifts. Meaning that teachers should understand not only the functions of a specific ICT, but also how to integrate the ICT in such a manner that it would bring about improved learning outcome. As McCormick & Scrimshaw (2001) point out, the potential of ICT may not be realised unless it is seen as more than just an aid to efficiency, or an extension device. Furthermore, they conclude that pedagogic change is necessary so that ICTs can becomes transformative devices to enhance teaching and learning.

It was also found in this study that Facilitating Conditions were not a predicting factor of participating teachers' actual use of ICT. Therefore, implying that even if adequate resources and technical support are available and teachers have sufficient knowledge of ICTs it does not mean that they will actually use it. This relates to the previous point, and emphasises the fact that it is not necessarily worthwhile for governments and schools to spend ample amounts of money on the latest ICTs if teachers lack the pedagogical knowledge to successfully integrate ICTs. On the other hand, this study also confirmed that Performance Expectancy and Social Influence did significantly predict if participating teachers would utilise ICT in their classroom or not, thereby indicating that teachers are more likely to use ICT if it improves their teaching performance and they see it being used by important people around them. This also indicates that teachers might only view ICT integration as beneficial when it increases productivity, and social influence. However, as the previous point mentions, the researcher suggested that ways should be found to motivate mathematics teachers to use ICTs not only to increase teacher productivity but also to foster pedagogical changes and improve conceptual understanding in the teaching and learning of mathematics.

According to Wilson (2000) the appropriate uses of ICT tools can support conceptual development and enable mathematical investigations among learners. This point is also emphasised by The National Council of Teachers of Mathematics (NCTM) as they recommend that learners use ICT to concentrate on problem-solving processes rather than on calculations related to the problems

(Ittigson & Zewe, 2003). This fundamental shift needed in teacher pedagogy, can perhaps be attained through professional development programmes that model functional pedagogical changes to teachers and could lead to improved mathematics education in South Africa. Furthermore, because of the strong positive effect of Social Influence on intentional use of ICT, it would be beneficial to get those that are in leadership positions such as principals and heads of departments to adopt and promote good use of ICTs.

5.1.7 Contributions of the Study and Recommendations

In light of the findings, contributions, implications and limitations of this study discussed above the following recommendations are made:

- Both frameworks (UTAUT an SAMR) utilised in this study are under presented in the literature, specifically within the South African educational context and further research exploring these frameworks should be done;
- Further research should be conducted probing how mathematic teachers use a specific ICTs for the teaching and learning process to bring about functional change;
- How video as an ICT could be utilised within schools and mathematics classrooms should be further investigated;
- Research should also be conducted on ways to better inform governments, principals, school governing bodies and department heads of how ICTs can be utilised to bring about functional change in pedagogical practices;
- Research can also be done to explore teachers' use of ICTs for specific mathematics school curriculum topics;
- Deeper research can be conducted to explore the relationship between ICT expenditure and the change it can bring in learning outcomes;

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7. ANNEXURES

7.1 ANNEXURE A – PERMISSION LETTER TO V.A.W.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

FACULTY OF EDUCATION
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07 June 2016

Letter of consent to the Vereniging vir Afrikaanse Wiskunde-onderwysers (V.A.W.)

Dear Dr/Mr/Ms

I hereby request permission to conduct research on V.A.W. members' integration of technology for the instruction of mathematics. I would like to invite mathematics teachers in the senior and/or FET phase to participate in this research aimed at investigating what, how and why mathematics teachers use technology in their classrooms. This research will be reported upon in my Master's dissertation at the University of Pretoria.

Before commencing the research I need 10 randomly selected teachers to fill in a short pilot questionnaire which could be e-mailed to them. This piloting will be used to rephrase questionnaire items if it seemed unclear. Once pilot testing is complete I would appreciate it if I could hand out hard copies of the (adjusted) questionnaire at some of the workshops and conferences. Both the pilot and final questionnaires should not take more than 5 - 10 minutes to complete (see the attached questionnaire). After workshops I would also like e-mails to be sent out to V.A.W.'s mailing list with the attached questionnaire as well as a link to a website hosting the questionnaire in order to increase the response rate and get the highest response rate possible. For the second phase of my study I would like to conduct semi-structured telephone interviews with 5-10 V.A.W. members. On the questionnaire, I will provide space for teachers to voluntarily add their contact details if they are willing to participate in an interview at a time convenient to the teacher. Teachers selected for interviewing will be asked for their consent to make audio recordings of the interviews.

All participation is voluntary and once committed to the research the V.A.W. and its members may still withdraw at any time. Confidentiality and anonymity will be guaranteed at all times by using pseudonyms for the V.A.W. members. V.A.W. members will therefore not be identifiable in the findings of my research and only my supervisor and I will have access to the audio recordings (if applicable) which will be password protected. The data collected will only be used for academic purposes.

After the successful completion of my Master's degree I will give feedback to V.A.W. in the form of a written report.

For any questions before or during the research, please feel free to contact me. If you are willing to allow members of your organisation to participate in this study, please sign this letter as a declaration of your consent.

Yours sincerely

______________________ ______________________
Researcher: Mr R Kapp Date

______________________ ______________________
Supervisor: Prof G Stols Date

I the undersigned, hereby grant consent to Mr R Kapp to conduct his research with V.A.W. members for his Master's research.

V.A.W. representative's name: ________________________

V.A.W. representative's signature: _____________________ Date: ________________

E-mail address: ______________________________ _____

Contact number: _____________________________ _____

7.2 ANNEXURE B – CONSENT FORM FOR PARTICIPATING TEACHERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

FACULTY OF EDUCATION
Mr. Ruan Kapp
Groenkloof campus
University of Pretoria
ruan@helpendehand.co.za
Cell: 071 874 9395

22 November 2016

Letter of Consent to the Mathematics Teacher

Dear Dr/Mr/Ms

You are invited to participate in a study aimed at investigating mathematics teachers' integration of ICT for the instruction of mathematics. This research will be reported upon in my master's dissertation at the University of Pretoria.

It is proposed that you form part of this study's data collection phase by completing a questionnaire which should not take more than 10 minutes to complete. I would furthermore like to invite you to participate in the second phase of the study via a semi-structured telephone interview. This interview will be conducted with 5-10 randomly selected V.A.W. members from those who indicated that they would like to participate in the second phase of the study. The telephone interview should take 10-20 minutes.

Your participation in this research is absolutely voluntary and confidential. You may still withdraw at any point in time from the study. Confidentiality and anonymity will be guaranteed at all times by using pseudonyms for all participants and participants will therefore not be identifiable in the findings of my research. Teachers selected for interviewing will be asked for their consent to make audio recordings of the interviews (to make transcription of the data easier) and only my supervisor and I will have access to the audio recordings (if applicable) which will be password protected. The collected data will only be used for academic purposes. After the successful completion of my Master's Degree I will give feedback to V.A.W. in the form of a written report which could be distributed to its members.

If you are willing to participate in this study (one or both phases), please sign this letter as a declaration of your consent, i.e. that you participate willingly and that you understand that you may withdraw at any time.

Yours sincerely

______________________ ________________________

Researcher: Mr. Ruan Kapp Date

______________________ ________________________

Supervisor: Prof. Gerrit Stols Date

I the undersigned, hereby consent to (please select the correct option for **all** three statements by indicating it with an X in the appropriate block):

1) filling out a questionnaire in phase one of the study

YES	NO

2) being telephonically interviewed by Mr R Kapp in the second phase of the study

YES	NO

3) be audio recorded if I consent to a telephone interview (I realise that recordings will only be used to aid the researcher with transcription of the data).

YES	NO

Participant's name and surname: ____

Participant's signature: ________________________ Date: ____________________

E-mail address: _____________________________ _

Contact number: ____________________________ _

7.3 ANNEXURE C – HARD COPY VERSION OF QUESTIONNAIRE

Mathematics teachers' integration of ICT in their classrooms

The Survey Study URL: To be completed

Important: When completing the survey, please keep in mind that ICT includes computer hardware (e.g. scanners, digital cameras, data projectors, interactive whiteboards, visualisers, etc.) and software applications (e.g. word processing, the Internet, PowerPoint, mathematics educational programs, webpage construction).

Instructions: Please select the correct option(s) by indicating it with an 'X' in the appropriate block(s), e.g. ☒

Section A: Demographic information of participating teacher

For office use only

1. What is your gender?

1) Male	2) Female

Q1 ☐

2. Which grade(s) did you teach mathematics for, during the last 5 years?

1	2	3	4	5	6	7	8	9	10	11	12

Q2 ☐

3. Which grade(s) are you currently teaching mathematics for?

1	2	3	4	5	6	7	8	9	10	11	12

Q3 ☐

4. In which province are you currently teaching?

1) Gauteng	2) Western Cape	3) Northern Cape	4) Free State	5) North West
6) Mpumalanga	7) KwaZulu-Natal	8) Limpopo	9) Eastern Cape	

Q4 ☐

5. Are you teaching in a city school, in a rural area or at a township school?

1) City school	2) Rural area	3) Township school

Q5 ☐

6. Are you teaching at a private or a government school?

1) Private school	2) Government school

Q6 ☐

7. Indicate your age range.

1) 17-19	2) 20-29	3) 30-39	4) 40-49	5) 50-59	6) 60-69	7) > 69

Q7 ☐

Section B: Which ICTs are used by the participating teacher for teaching mathematics?

Instructions:
Please select the number that best describes your usage of a particular ICT.

1	2	3	4
Never	Rarely	Sometimes	Often

Item no.	Type of ICT	The ICT is accessible to me		How do you use each of the ICTs?												For office use only
				In class for teaching				For preparation				Own Personal Development				
8.1	Personal Computer/Laptop	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.1
8.2	The Internet	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.2
8.3	Mobile Devices (e.g. cell phones or tablets)	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.3
8.4	Radio	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.4
8.5	Intranet (e.g. school network)	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.5
8.6	Television	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.6
8.7	CD ROM/DVDs	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.7
8.8	Scanner	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.8
8.9	Printer	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.9
8.10	E-Mail	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.10
8.11	Overhead Projector	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.11
8.12	Video Camera	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.12
8.13	Data Projector	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.13
8.14	Smart Board/Interactive Board	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.14
8.15	Document Camera/ Visualizer	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.15

Item no.	Type of ICT	The ICT is accessible to me		How do you use each of the ICTs?												For office use only
				In class for teaching				For preparation				Own Personal Development				
8.16	Microsoft Word	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.16
8.17	Microsoft Excel	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.17
8.18	Microsoft PowerPoint	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.18
8.19	Facebook	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.19
8.20	Twitter	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.20
8.21	Skype	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.21
8.22	Instagram	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.22
8.23	WhatsApp Messenger	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.23
8.24	Video Conference	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.24
8.25	YouTube Videos	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.25
8.26	Explain Everything	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.26
8.27	Google Docs	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.27
8.28	Blogs	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.28
8.29	Learner Management System (LMS) (e.g. Edmodo, Moodle, Blackboard etc.)	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.29
8.30	Drop Box	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.30
8.31	Note Sharing (e.g. Evernote, Onenote etc.)	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.31
8.32	Webinars	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.32
8.33	e-Portfolios	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.33
8.34	Dynamic Mathematics software (e.g. GeoGebra)	Yes	No	1	2	3	4	1	2	3	4	1	2	3	4	Q8.34

Please specify any other ICT that you use for teaching of mathematics in the classroom.

Item no.	ICTs	In class for teaching				For preparation				Own Personal Development			
8.35		1	2	3	4	1	2	3	4	1	2	3	4
8.36		1	2	3	4	1	2	3	4	1	2	3	4

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Q8.35

Q8.36

Section C: Reasons for applying the use of ICT in teaching and learning

Instructions:
Please select the number that best describes your agreement or disagreement with each statement.
Please note: *Teaching refers to the teaching of mathematics*.

1	2	3	4	5
Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree

Item no. 9

Item No	Statement	1	2	3	4	5
9.1	ICT is useful for teaching graphs.	1	2	3	4	5
9.2	It is easy to use ICT for teaching graphs.	1	2	3	4	5
9.3	My HOD or Subject head thinks that I should use ICT for teaching mathematics in the classroom.	1	2	3	4	5
9.4	I have the resources necessary to use ICT to teach mathematics in the classroom.	1	2	3	4	5
9.5	ICT is useful for teaching statistics.	1	2	3	4	5
9.6	It is easy to use ICT for teaching statistics.	1	2	3	4	5
9.7	My principal thinks that I should use ICT for teaching mathematics in the classroom.	1	2	3	4	5
9.8	I have the knowledge necessary to use ICT for teaching mathematics in the classroom.	1	2	3	4	5
9.9	ICT is useful for teaching calculus.	1	2	3	4	5

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Q9.1
Q9.2
Q9.3
Q9.4
Q9.5
Q9.6
Q9.7
Q9.8
Q9.9

9.10	It is easy to use ICT for teaching calculus.	1	2	3	4	5	Q9.10	☐
9.11	The school governing body thinks that I should use ICT for teaching mathematics in the classroom.	1	2	3	4	5	Q9.11	☐
9.12	It is possible for me to use ICT to teach mathematics in the classroom.	1	2	3	4	5	Q9.12	☐
9.13	ICT is useful for teaching geometry.	1	2	3	4	5	Q9.13	☐
9.14	It is easy to use ICT for teaching geometry.	1	2	3	4	5	Q9.14	☐
9.15	My colleagues think that I should use ICT for teaching mathematics in the classroom.	1	2	3	4	5	Q9.15	☐
9.16	A specific person (or group) would be available for assistance with difficulties when using ICT to teach mathematics in the classroom.	1	2	3	4	5	Q9.16	☐
9.17	ICT is useful for teaching analytical geometry.	1	2	3	4	5	Q9.17	☐
9.18	It is easy to use ICT for teaching analytical geometry.	1	2	3	4	5	Q9.18	☐
9.19	It is easy to use ICT for teaching algebra.	1	2	3	4	5	Q9.19	☐
9.20	ICT is useful for teaching algebra.	1	2	3	4	5	Q9.20	☐
9.21	Using ICT to teach mathematics in the classroom will enhance learners' understanding.	1	2	3	4	5	Q9.21	☐
9.22	Using ICT mathematics concepts could be explained in a way that learners grasp the concepts quicker than they would have if conventional (board and chalk) methods were used.	1	2	3	4	5	Q9.22	☐
9.23	In general, it is easy to use ICT for teaching mathematics	1	2	3	4	5	Q9.23	☐
9.24	Using ICT to teach mathematics in the classroom will make it easier to explain difficult concepts.	1	2	3	4	5	Q9.24	☐
9.25	Learning to use ICT to teach mathematics in the classroom would be easy for me	1	2	3	4	5	Q9.25	☐
9.26	Using ICT to teach mathematics in the classroom saves time	1	2	3	4	5	Q9.26	☐
9.27	Using ICT for teaching in the classroom would increase my productivity.	1	2	3	4	5	Q9.27	☐
9.28	If I use ICT for teaching in the classroom, I will increase my employment opportunities.	1	2	3	4	5	Q9.28	☐
9.29	I intent to use ICT to teach mathematics in the classroom in the next 6 months	1	2	3	4	5	Q9.29	☐

Section D: Application of ICT during a mathematics lesson.

Instructions:
Please fill in you answer to the questions below in the open spaces provided.
Please note: *Teaching refers to the teaching of mathematics*.

Item no. 10.1
What ICTs according to you has the biggest impact on the teaching and learning of mathematics.

Item no. 10.2
How do you apply the ICT mentioned above in a typical mathematics lesson?

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Q10.1

Q10.2

For office use only

Section E: Actual application of ICT.

Instructions:
Please mark the number that best describes your agreement or disagreement with each statement.
Please note: *Teaching refers to the teaching of mathematics*.

Item no. 11.1: Actual use
Please indicate the frequency with which you intend to use ICT for teaching mathematics during the next 6 months, by encircling the most appropriate answer.

Frequency:	**Marking (X)**
1) I do not plan to use ICT at all	
2) Only once	
3) Once a month	
4) Once every two weeks	
5) Once or twice a week	
6) Three to four times a week	
7) Daily	

Q11.1

Item no. 11.2: Actual use
Please indicate the frequency with which you are using ICT for teaching mathematics at this stage, by encircling the most appropriate answer.

Frequency:	**Marking (X)**
1) I do not plan to use ICT at all	
2) Only once	
3) Once a month	
4) Once every two weeks	
5) Once or twice a week	
6) Three to four times a week	
7) Daily	

Q11.2

7.4 ANNEXURE D – WHAT ICTS ARE UITLISED BY PARTICIPATING TEACHERS

7.4.1 Percentage of teachers indicating what ICTs are currently available and/or accessible to them for the teaching and learning of mathematics

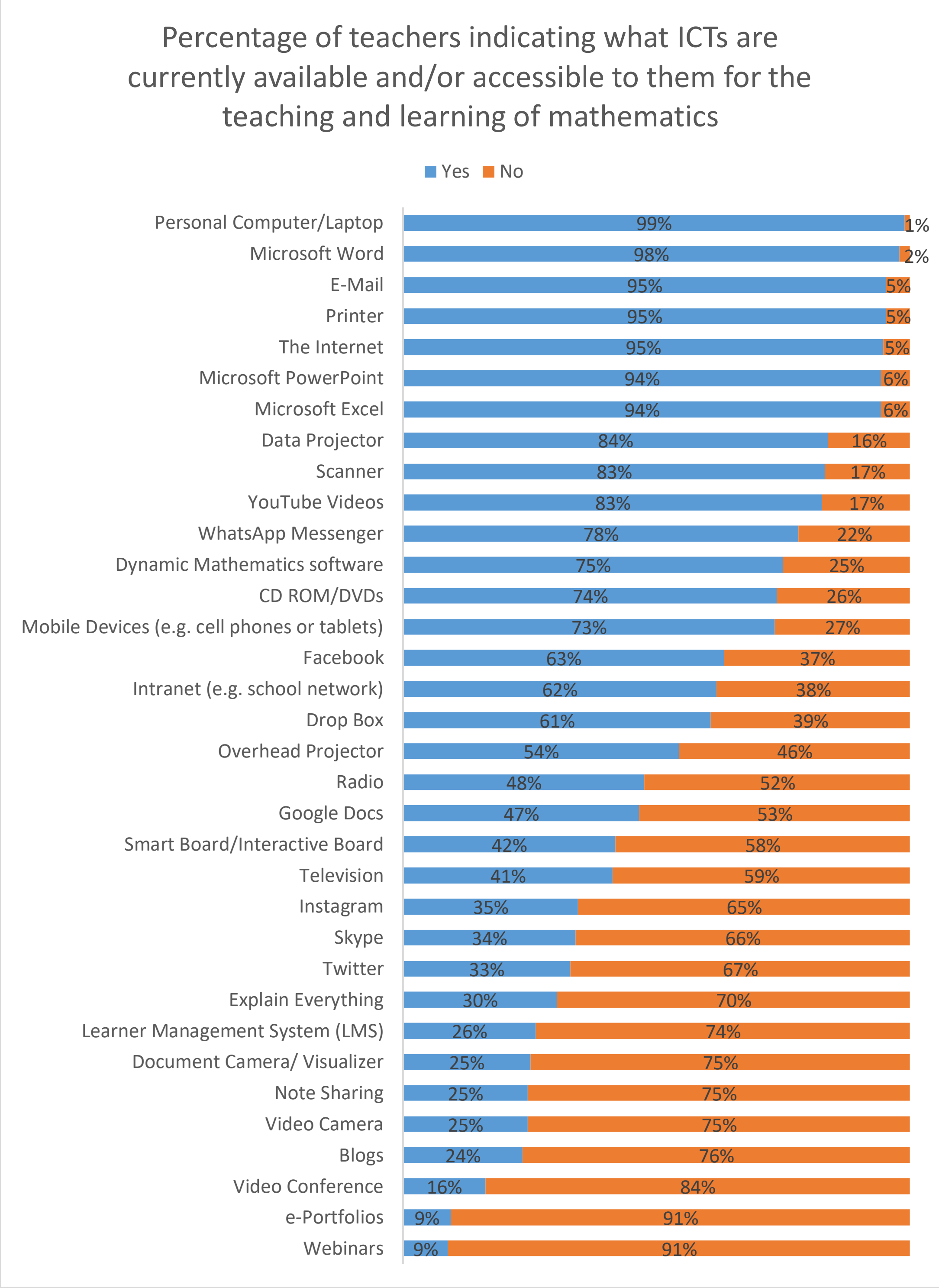

Chart 7.1 : Percentage of teachers indicating what ICTs are currently available and/or accessible to them for the teaching and learning of mathematics.

7.4.2 Percentage of teachers indicating how often a particular ICT is currently being utilised for the teaching and learning of mathematics

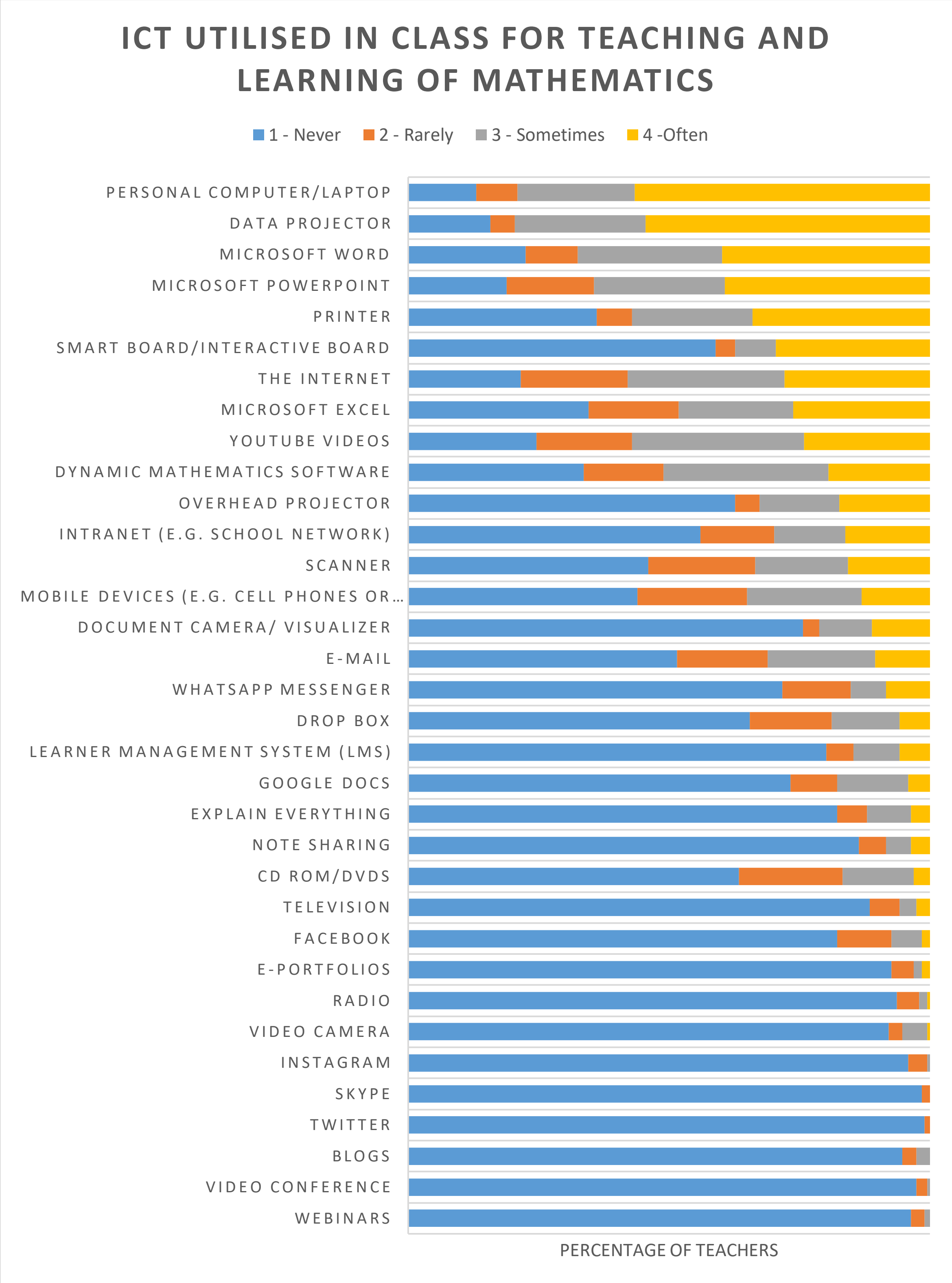

Chart 7.2 : Percentage of teachers indicating how often a particular ICT is currently being used for the teaching and learning of mathematics.

7.4.3 Percentage of teachers indicating how often a particular ICT is currently being utilised for the preparation for the teaching and learning of mathematics

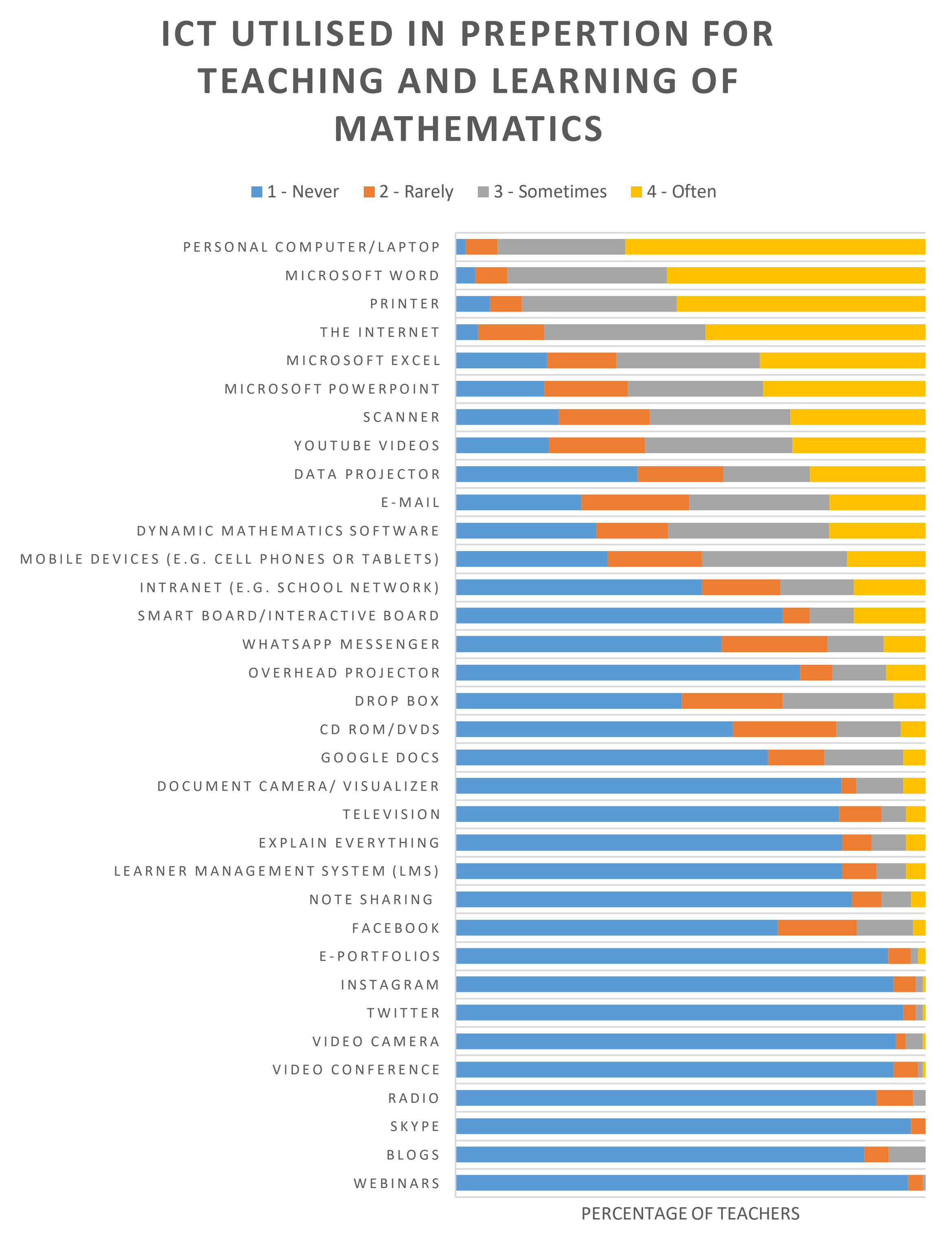

Chart 7.3 : Percentage of teachers indicating how often a particular ICT is currently being utilised for the preparation for the teaching and learning of mathematics

7.4.4 Percentage of teachers indicating how often a particular ICT is currently being used for own professional development.

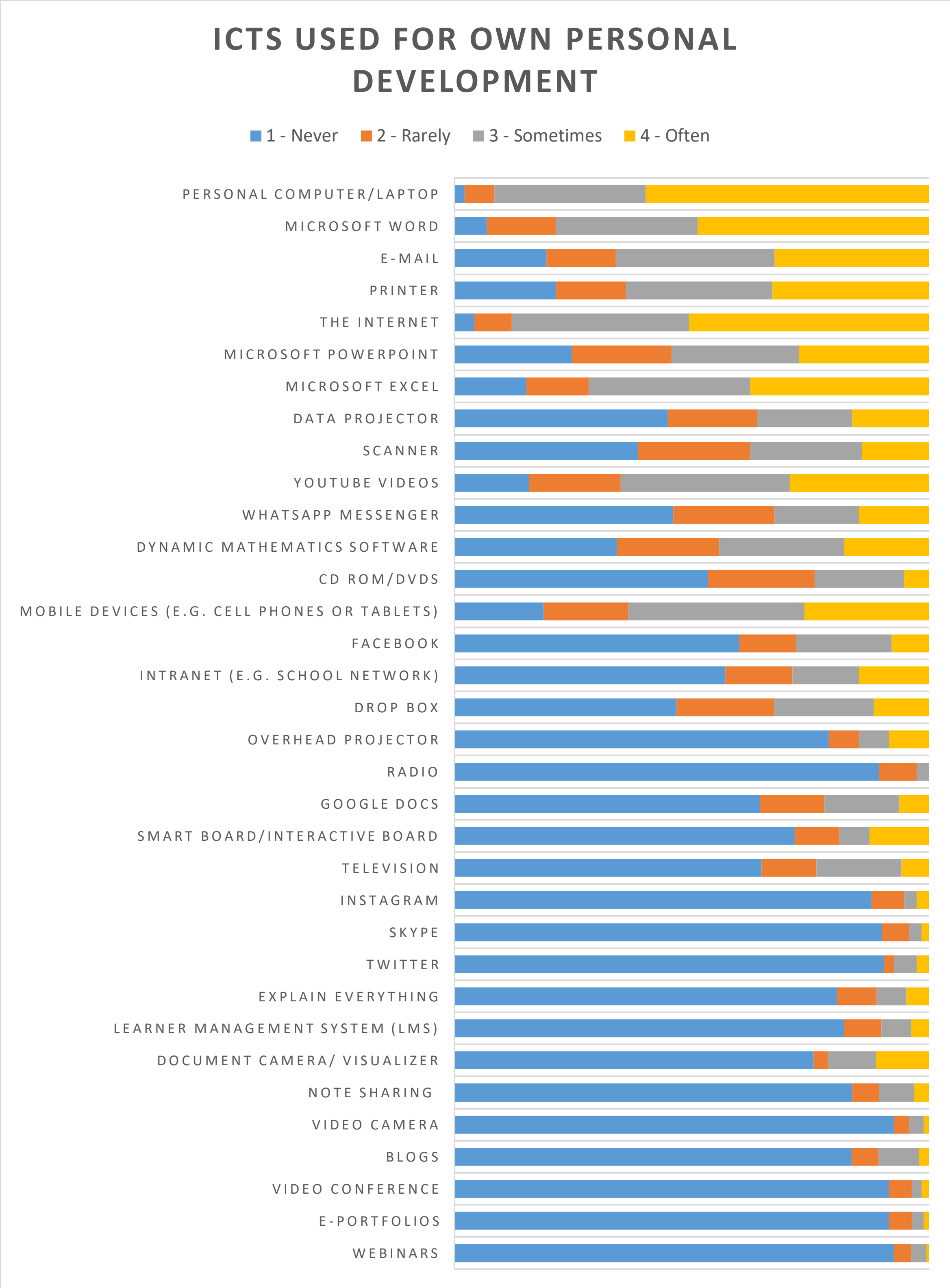

Chart 7.4 : Percentage of teachers indicating how often a particular ICT is currently being used for own professional development.

7.5 ANNEXURE E – MISSING VALUES

The number of missing values per item

Question	N	Mean	Std. Deviation	Missing		No. of Extremes	
				Count	Percent	Low	High
Q9.1	191	4.46	0.983	0	0	14	0
Q9.2	191	4.17	1.113	0	0	19	0
Q9.3	191	3.80	1.339	0	0	0	0
Q9.4	191	3.81	1.348	0	0	0	0
Q9.5	191	4.08	1.156	0	0	0	0
Q9.6	191	3.86	1.195	0	0	0	0
Q9.7	191	3.62	1.405	0	0	0	0
Q9.8	191	3.77	1.251	0	0	0	0
Q9.9	191	3.86	1.208	0	0	0	0
Q9.10	191	3.52	1.277	0	0	0	0
Q9.11	191	3.58	1.419	0	0	0	0
Q9.12	191	4.02	1.320	0	0	0	0
Q9.13	191	4.48	1.030	0	0	16	0
Q9.14	191	4.03	1.222	0	0	0	0
Q9.15	191	3.68	1.349	0	0	0	0
Q9.16	191	3.17	1.434	0	0	0	0
Q9.17	191	3.99	1.163	0	0	0	0
Q9.18	191	3.74	1.249	0	0	0	0
Q9.19	191	3.61	1.317	0	0	0	0
Q9.20	191	3.73	1.284	0	0	0	0
Q9.21	191	3.87	1.254	0	0	0	0
Q9.22	191	3.95	1.146	0	0	0	0
Q9.23	191	3.74	1.228	0	0	0	0
Q9.24	191	3.97	1.137	0	0	0	0
Q9.25	191	4.02	1.183	0	0	0	0
Q9.26	191	4.02	1.254	0	0	0	0
Q9.27	191	4.04	1.176	0	0	0	0
Q9.28	191	3.99	1.194	0	0	0	0

7.6 ANNEXURE F – CFA MODEL FIT SUMMARY FOR COMPLETE THEORETICAL MODEL

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	62	1493.891	344	.000	4.343
Saturated model	406	.000	0		
Independence model	28	5930.824	378	.000	15.690

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.086	.648	.585	.549
Saturated model	.000	1.000		
Independence model	.836	.101	.035	.094

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.748	.723	.794	.772	.793
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.910	.681	.722
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	1149.891	1034.006	1273.295
Saturated model	.000	.000	.000
Independence model	5552.824	5306.768	5805.299

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	7.863	6.052	5.442	6.702
Saturated model	.000	.000	.000	.000
Independence model	31.215	29.225	27.930	30.554

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.133	.126	.140	.000
Independence model	.278	.272	.284	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	1617.891	1640.226	1819.532	1881.532
Saturated model	812.000	958.261	2132.423	2538.423
Independence model	5986.824	5996.911	6077.888	6105.888

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	8.515	7.905	9.165	8.633
Saturated model	4.274	4.274	4.274	5.043
Independence model	31.510	30.215	32.838	31.563

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	50	52
Independence model	14	15

Standardised regression weights for the complete theoretical model

Item no.			Estimate	Item no.			Estimate
Q9.1	<---	F1	.725	Q9.14	<---	F2	.871
Q9.5	<---	F1	.741	Q9.18	<---	F2	.861
Q9.9	<---	F1	.792	Q9.19	<---	F2	.799
Q9.13	<---	F1	.720	Q9.23	<---	F2	.862
Q9.17	<---	F1	.795	Q9.25	<---	F2	.839
Q9.20	<---	F1	.709	Q9.7	<---	F3	.895
Q9.21	<---	F1	.770	Q9.11	<---	F3	.885
Q9.22	<---	F1	.800	Q9.15	<---	F3	.882
Q9.24	<---	F1	.848	Q9.4	<---	F4	.759
Q9.26	<---	F1	.814	Q9.8	<---	F4	.831
Q9.27	<---	F1	.868	Q9.12	<---	F4	.788
Q9.28	<---	F1	.814	Q9.16	<---	F4	.552
Q9.2	<---	F2	.844	Q9.3	<---	F3	.839
Q9.6	<---	F2	.831	Q9.10	<---	F2	.838

7.7 ANNEXURE G – SEM MODEL FIT SUMMARY FOR COMPLETE THEORETICAL MODEL

Testing the null hypothesis that the model is correct, Bollen-Stine bootstrap p = .241

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	35	108.260	70	.002	1.547
Saturated model	105	.000	0		
Independence model	14	2430.060	91	.000	26.704

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.059	.925	.888	.617
Saturated model	.000	1.000		
Independence model	.877	.195	.071	.169

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.955	.942	.984	.979	.984
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.769	.735	.757
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	38.260	14.005	70.460
Saturated model	.000	.000	.000
Independence model	2339.060	2182.038	2503.430

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.570	.201	.074	.371
Saturated model	.000	.000	.000	.000
Independence model	12.790	12.311	11.484	13.176

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.054	.032	.073	.364
Independence model	.368	.355	.381	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	178.260	184.260	292.090	327.090
Saturated model	210.000	228.000	551.489	656.489
Independence model	2458.060	2460.460	2503.592	2517.592

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.938	.811	1.108	.970
Saturated model	1.105	1.105	1.105	1.200
Independence model	12.937	12.111	13.802	12.950

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	159	177
Independence model	9	10

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
BI	<---	PE	.422	.183	2.302	.021	
BI	<---	EE	.262	.179	1.466	.143	
BI	<---	SI	.365	.085	4.315	***	
USE	<---	BI	.651	.091	7.165	***	
Q9.24	<---	PE	1.000				
Q9.27	<---	PE	1.002	.066	15.158	***	
Q9.2	<---	EE	1.000				
Q9.14	<---	EE	1.134	.070	16.137	***	
Q9.18	<---	EE	1.083	.076	14.323	***	
Q9.23	<---	EE	1.109	.072	15.362	***	

			Estimate	S.E.	C.R.	P	Label
Q9.25	<---	EE	1.081	.069	15.700	***	
Q9.7	<---	SI	1.116	.070	15.888	***	
Q9.11	<---	SI	1.114	.072	15.567	***	
Q9.15	<---	SI	1.064	.068	15.685	***	
Q9.3	<---	SI	1.000				
Q9.29	<---	BI	1.000				
Q11.1	<---	USE	1.000				
Q11.2	<---	USE	1.184	.074	15.910	***	

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
BI	<---	PE	.332
BI	<---	EE	.194
BI	<---	SI	.320
USE	<---	BI	.598
Q9.24	<---	PE	.886
Q9.27	<---	PE	.858
Q9.2	<---	EE	.853
Q9.14	<---	EE	.880
Q9.18	<---	EE	.823
Q9.23	<---	EE	.857
Q9.25	<---	EE	.867
Q9.7	<---	SI	.893
Q9.11	<---	SI	.882
Q9.15	<---	SI	.886
Q9.3	<---	SI	.839
Q9.29	<---	BI	1.004
Q11.1	<---	USE	.938
Q11.2	<---	USE	.939

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
PE	<-->	EE	.829	.106	7.809	***	
PE	<-->	SI	.765	.114	6.702	***	
EE	<-->	SI	.693	.106	6.563	***	

Correlations: (Group number 1 - Default model)

			Estimate
PE	<-->	EE	.872
PE	<-->	SI	.679
EE	<-->	SI	.653

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label

	Estimate	S.E.	C.R.	P	Label
PE	1.010	.135	7.485	***	
EE	.896	.124	7.240	***	
SI	1.256	.178	7.041	***	
e32	.675	.164	4.122	***	
e33	1.245	.173	7.181	***	
e9	.277	.049	5.681	***	
e11	.362	.054	6.649	***	
e13	.336	.041	8.139	***	
e16	.334	.044	7.658	***	
e17	.502	.059	8.487	***	
e19	.399	.049	8.080	***	
e20	.345	.044	7.912	***	
e21	.526	.065	8.110	***	
e22	.397	.057	7.011	***	
e23	.444	.061	7.313	***	
e24	.389	.054	7.208	***	
e29	-.013	.146	-.088	.930	
e30	.264	.103	2.565	.010	
e31	.365	.144	2.531	.011	

Residual Covariances (Group number 1 - Default model)

	Q11.2	Q11.1	Q9.29	Q9.15	Q9.11	Q9.7	Q9.3	Q9.25	Q9.23	Q9.18	Q9.14	Q9.2	Q9.27	Q9.24
Q11.2	.000													
Q11.1	.000	.000												
Q9.29	.000	.000	.000											
Q9.15	-.023	-.011	.044	.000										
Q9.11	.045	.047	-.001	-.049	.000									
Q9.7	.019	-.003	-.051	.004	.055	.000								
Q9.3	.027	.062	.014	.039	-.006	-.048	.000							
Q9.25	.031	.049	-.019	-.005	-.119	-.163	.046	.000						
Q9.23	.223	.111	.093	.152	.105	.083	.108	.005	.000					
Q9.18	.072	.078	.015	.056	.046	-.023	.047	-.054	-.015	.000				
Q9.14	.029	.038	-.054	.054	-.030	-.059	.069	.006	-.003	.023	.000			
Q9.2	.103	.114	-.015	-.048	-.066	-.132	.048	.002	-.032	.038	.021	.000		
Q9.27	-.145	-.083	.028	-.002	.010	-.077	.011	.033	-.001	.026	-.069	.001	.000	
Q9.24	-.121	-.078	-.023	-.007	-.022	.040	.051	.078	.020	-.021	-.029	-.033	.000	.000

Standardized Residual Covariances (Group number 1 - Default model)

	Q11.2	Q11.1	Q9.29	Q9.15	Q9.11	Q9.7	Q9.3	Q9.25	Q9.23	Q9.18	Q9.14	Q9.2	Q9.27	Q9.24
Q11.2	.000													
Q11.1	.000	.000												
Q9.29	-.001	.001	.000											
Q9.15	-.126	-.073	.303	.000										
Q9.11	.236	.291	-.005	-.278	.000									
Q9.7	.102	-.020	-.338	.020	.301	.000								
Q9.3	.150	.413	.098	.239	-.035	-.282	.000							
Q9.25	.197	.365	-.147	-.039	-.878	-1.216	.360	.000						
Q9.23	1.35	.799	.709	1.13	.749	.593	.821	.039	.000					

	Q11.2	Q11.1	Q9.29	Q9.15	Q9.11	Q9.7	Q9.3	Q9.25	Q9.23	Q9.18	Q9.14	Q9.2	Q9.27	Q9.24
	5			8										
Q9.18	.431	.554	.116	.413	.327	-.166	.354	-.410	-.113	.000				
Q9.14	.177	.275	-.409	.402	-.211	-.424	.524	.044	-.020	.172	.000			
Q9.2	.691	.905	-.124	-.394	-.519	-1.051	.407	.016	-.264	.309	.169	.000		
Q9.27	-.915	-.620	.222	-.018	.075	-.573	.085	.274	-.005	.208	-.556	.005	.000	
Q9.24	-.789	-.605	-.183	-.057	-.167	.308	.415	.666	.168	-.175	-.235	-.304	.000	.000