Investigating the effects of continuous professional development on ICT integration in the classroom of Foundation Phase mathematics.

A thesis submitted in fulfillment of the requirements for the degree of Magister Educationis in Mathematics Education in the Faculty of Education, University of the Western Cape

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Abstract

The use of technology is becoming the norm in the 21st century classroom to enhance teaching and learning. This rapid move to incorporate technology in the classroom brought the need for teachers to be upskilled on the use of technology as a pedagogical tool. Through this study the researcher sought to investigate the effects that Continuous Professional Development (CPD) has on Information and Communications Technology (ICT) integration in the classroom, with a specific focus on the teaching and learning of mathematics in the Foundation Phase. The mixed method research design will be underpinned by the conceptual approach of the Technological Pedagogical Content Knowledge (TPACK) and Substitution, Augmentation, Modification and Redefinition (SAMR) frameworks and supported by a constructivist learning theory approach to the teaching and learning of mathematics. The TPACK framework builds on Lee Shulman's construct of Pedagogical Content Knowledge (PCK) which integrates technological knowledge. Through the analysis of data in the study the researcher found that although teachers are trained in using ICT there are factors that hinder the successful integration of these acquired skills in the Foundation Phase mathematics classroom.

Title: Investigating the effects of continuous professional development on ICT integration in the classroom of Foundation Phase mathematics.

Initial and surname of researcher: C. Senosi

Name of degree: MEd, Faculty of Education, University of the Western Cape

Date: December 2022

Declaration

I Chloé Emma Senosi declare that *Investigating the effects of continuous professional development on ICT integration in the classroom of Foundation Phase mathematics* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name: Chloé Emma Senosi **Date:** December 2022

Signed.....

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This degree would not be possible without God's continuous grace and blessings over my life. Faith carried me through my journey as I looked to Philippians 4:13 "**I can do all things through Christ who gives me strength**" for inspiration, especially during difficulties.

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Dedication

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Abbreviations

CAPS	Curriculum Assessment Policy Statement
CK	Content Knowledge
COVID-19	Coronavirus Disease 2019
CPD	Continuous Professional Development
CPTD	Continuing Professional Teacher Development
CTLI	Cape Teaching and Leadership Institute
DBE	Department of Basic Education
DoE	Department of Education
ICT	Information and Communications Technology
IWB	Interactive Whiteboard
LCD	Liquid Crystal Display
MCO	Maths Curriculum Online
MMCSR	Mixed Method Case Study Research
MSED	Metro South Education District
NCTM	National Council of Teachers of Mathematics
NRC	National Research Council
PC	Personal Computer
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SAMR	Substitution Augmentation Modification Redefinition
TCK	Technological Content Knowledge
TK	Technological Knowledge
TPK	Technological Pedagogical Knowledge
TPACK	Technological Pedagogical And Content Knowledge

TTF Teaching Teachers for the Future

WCED Western Cape Education Department

Chapter One
Background and overview of the study

1.1) Introduction

Over the last decade, ICT integration has rapidly become a norm in many schools. Teachers' and learners are making use of various ICT devices such as smartboards and tablets to enhance learning (Ghavifekr, Razak, Ghani, Ran, Meixi & Tengyue, 2014). Inventions like overhead projectors were one of the first glimpses of emerging technologies in classrooms in the 1960's (Akanegbu, 2013). Years later, we find ourselves with a range of ICT equipment, smart devices, and applications to aid teaching and learning. Due to the global pandemic, schools have relied more on technology to continue teaching and learning. This situation is not unique to South Africa, but it has been proven worldwide that there are new, alternative methods of pedagogy. With this new need for ICT integration comes a need for teacher training on how to effectively integrate ICT into teaching and learning.

The Foundation Phase (Grades R to three) is the first phase of formal schooling learners in South Africa.Foundation Phase teachers are a specialized group of teachers' that focus on the basics of literacy and numeracy. Numeracy is important at this stage because it sets the foundation for the children's acquisition of mathematics at the onset of their schooling and as they progress through their schooling (Jordan, Kaplan, Ramineni, & Locuniak, 2009) and thus training is vital for Foundation Phase teachers to improve the teaching and learning of numeracy. In the current context of the use of alternative methods of pedagogy such as ICT, it is imperative that teachers are continuously trained and kept abreast of the development of ICT as a pedagogical tool. Hence, the purpose of this study was to explore whether there were adequate continuous professional development programmes aimed at upskilling teachers on ICT integration in the Foundation Phase mathematics classroom and look at the effects that these programmes had on ICT integration in mathematics teaching and learning.

1.2) Background and motivation

In 2003 the minister of Basic Education drafted an e-Education white paper which set out the intention of e-Education and the goals of the Department of Basic Education (DBE). The e-Education white paper is the government's response to a new ICT environment in the classroom

(Department of Education, 2003).

The white paper states:

"*Every South African learner in the general and further education and training bands will be ICT capable (that is, use ICT confidently and creatively to help develop the skills and knowledge they need, to achieve personal goals and to be full participants in the global community by 2013)*" (Department of Education, 2003).

It has been nine years since the target date for the policy implementation of ICT was declared and this has not been fully achieved. However, many schools have made progress in becoming ICT capable by installing various ICT tools, as well as encouraging learners to use their mobile devices at school (Pegrum, Oakley, & Faulkner, 2013). This situation is not unique to South Africa. In 2007, the Australian government created a policy called the Digital Education Revolution (DER) (Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015). The purpose of the DER was "to ensure that all students would complete schooling with knowledge and skills foc using ICT in employment and that learning across the curriculum would be enhanced by the application of ICT" (Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015, p. 6).

One of the goals set out by these education departments and policy makers was that teachers should be trained on the use of these digital devices. It is pointless having a white paper set out and ICT equipment installed in schools if the teachers' who are meant to use these ICT tools are not adequately trained. "National policies need to make more commitment to helping teachers' effectively integrate computers and internet technologies into the classroom by aligning curricula, exams, and incentives with the educational outcomes that they hope to gain. In the end, computers by themselves bring very little to the learning process – they are only tools for teaching and learning" (Hennessy, Harrison & Wamakote, 2010, p. 43). Teachers require the necessary skills, pedagogical knowledge, resource tools, confidence, and support to effectively use online tools and systems to engage learners (AICTEC, 2009). Hence the importance of CPD to assist teachers' with enhancing learners mathematical understanding.

The professional development of teachers' sits at the heart of any successful technology and education programme. Several studies have found that one of the main barriers to teachers' integrating ICT into classrooms are a lack of proper training (Agyei, & Voogt, 2011) (Jones, 2004) (Afshari, Bakar, Luan, Samah, & Fooi, 2009). Teachers lack of confidence has also been shown to be one of the barriers to the proper and effective implementation of technology for effective teaching and learning. Jones (2004) sheds light on the direct link between teacher

confidence and teacher competence (Jones, 2004) stating that "if training is inadequate or inappropriate, then teachers will not be sufficiently prepared, and perhaps not sufficiently confident, to make full use of technology in and out of the classroom" (Jones, 2004, p. 8).

There are active attempts worldwide to develop continuous professional development. There have been many projects worldwide for the continuous professional development of teachers on ICT integration in schools for example, the Intel Teach project that has reached over six million teachers in 40 countries worldwide (Hennessy, Harrison & Wamakote, 2010). Since the 2007 Australian policy was initiated, it was found that teachers lack the technological pedagogical knowledge and because of this, the Teaching Teachers for the Future (TTF) project was implemented in Australia (Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015). On the African continent, there has been successful continuous professional development initiatives to get teachers to be knowledgeable about technology and know-how to effectively make use of it in teaching and learning, such as the World Links programmes in Ghana and Uganda and the Commonwealth of Learning Southern Africa Teacher Training Programme (Hennessy, Harrison & Wamakote, 2010). There have also been initiatives like Green Shoots, which is an online tool for learners to use for Mathematics throughout Africa.

Locally, in the Western Cape province of South Africa, the Cape Teaching and Leadership Institute (CTLI) offers a variety of courses for teachers' and school leaders. Some of which include ICT integration courses. Courses such as 'Google Essentials for Teachers' is one of the courses offered by CTLI in 2022 which focuses on introducing "teachers to Google Workplace Apps as tools to use in both virtual and traditional classroom spaces" (Cape Teaching and Leadership Institute, 2022). Although there is much literature on continuous professional development and integrating ICT into Foundation Phase teaching and learning, there seems to be a gap in the literature when it comes to CPD programmes on ICT integration in Foundation Phase mathematics teaching and learning.

According to Landry (2010), teachers can make use of the Technological, Pedagogical and Content Knowledge (TPACK) framework to assist them in integrating ICTs into teaching and learning in order create meaningful teaching and learning experiences. "A teacher who demonstrates the ability to negotiate the dynamic interaction of mathematics content, pedagogy and technology possesses a unique form of expertise, namely TPACK" (Spangenberg & De Freitas, 2019, p. 2). Spangenberg & De Freitas (2019) takes this further by stating that

mathematics teachers should use the TPACK framework in their ICT integration. There are gaps in developing teacher's knowledge of ICT and how teachers can effectively integrate ICT, as well as how the TPACK framework can be used to develop continuous professional development for teachers in ICT integration.

Hence the motivation to do this study. Policymakers globally have pushed schooling into a direction which makes use of technology with a major focus has been put on upgrading schools with technology and integrating that into the curriculum, teaching and learning. However, the same emphasis should be put on upskilling those who are expected to carry out this integration, the teachers. "The use of ICT in the classroom has long been advocated by policy-makers in education. However, despite the setting up of costly ICT infrastructure in schools, students have yet to reap the full benefits of the new technology, as not all teachers integrate ICT in the classroom" (Mirzajani, Mahmud, Ayub, & Wong, 2016, p. 36). "The teacher has an important role to play in the teaching/learning paradigm shift" (Afshari, Bakar,Luan, Samah, & Fooi, 2009). Annually, teachers' are workshopped and trained on curriculum and curriculum delivery to make teaching and learning effective. So why not workshop and train teachers' regularly on ICT integration? Just like any new curriculum training, ICT needs the same emphasis if we are going to successfully implement it into classroom practice. This can be seen in Bottino (2003) highlighting the rethinking of teacher training states that "Teachers' need to be given the training to operate effectively in ICT-rich environments andthe 'space' within their school work to take advantage of the potential it offers" (Bottino, 2003, p. 5).

1.3) Problem statement

Based on the literature, we see that one of the main barriers to successful ICT integration is teacher competence (Jones, 2004). Efforts have been made globally to upskill teachers on ICT integration (Hennessy, Harrison & Wamakote, 2010; Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015). However, education programmes aimed at training often focus on "teaching about technology instead of teaching with technology" (Afshari, Bakar, Luan, Samah, & Fooi, 2009, p.89). Although significant effort has been made to upskill teachers on ICT integration,there is a gap in literature. For example little research explores CPD programmes which focus on ICT integration in Foundation Phase mathematics. The purpose of this study is therefore to explore the effects ICT focused CPD programmes have on the integration of ICT into Foundation Phase mathematics teaching and learning.

1.4) Research objectives

The aim of this study is to investigate the effects that ICT continuous professional development programmes has on the integration of ICT in Foundation Phase Mathematics teaching and learning. To buttress the aim of this study the researcher has the following research objectives and asks the following research questions.

Research objectives:

- To explore the nature of continuous professional development on ICT integration in the Foundation Phase.
- To investigate the effects continuous professional development has on ICT integration in the Foundation Phase mathematics classroom.
- To explore the effects of that continuous professional development has on ICT integration in the teaching of mathematics in the Foundation Phase
- To explore the effects of that continuous professional development has on ICT integration in the learning of mathematics in the Foundation Phase.

1.5) Research questions

Main research question:

What are the effects of continuous professional development on ICT integration in Foundation Phase mathematics teaching and learning?

Sub questions:

- What is the nature of continuous professional development on ICT integration in the Foundation Phase?
- What impact does continuous professional development have on the integration of ICT in the teaching of mathematics in the Foundation Phase?
- What impact does continuous professional development have on the integration of ICT in the learning of mathematics in the Foundation Phase?
- To what extent does Foundation Phase ICT integration continuous professional development programmes impact teachers' Technological Pedagogical And Content Knowledge (TPACK)?

1.6) Significance of study

Teacher training does not end when one receives ones teaching qualification, it is an on-going process of professional development that spans over one's career. With every new concept, curriculum or idea introduced in education teachers are updated with the latest skills and methods. ICT skill development should not be any different. Teacher training on ICT integration is vital to a developing world with our 21st century learner needs. This study bares significance because it:

- Speaks from the perspectives of the teachers and touches on the experiences of both the teachers and the learners through the classroom observations. The interviews and questionnaire responses give valuable insights into teachers experiences of ICT integration courses and its impact on the teaching and learning of mathematics.

- Sheds light on a need for more CPD programmes on ICT integration that is specific to mathematics. Through this study we can see a clear need for more programmes that focus on teaching skills to strength mathematics, assist teachers to integrate the concrete with the technological and guide teachers on free applications and websites to use.

- Speaks to the benefits of ICT integration on teachers' time and the financial benefits in the long run for schools and thus it is valuable to upskill our teachers in order to gain from these benefits.

1.7) Chapter outline

This thesis consists of six chapters:

Chapter one

Chapter one consists of the introduction and background and motivation for the study. In addition to this the chapter states the problem statement, outlines the research questions and objectives, and details the significance of the study.

Chapter two

Chapter two gives a review of the literature used in this study that speaks to the research question of continuous professional development programmes of ICT integration in Foundation Phase mathematics. This chapter looks at literature under the following headings:

ICT in education, continuous professional development, continuous professional development programmes and continuous professional development in the integration of ICT into the Foundation Phase mathematics classroom and ICT tools and applications for teaching and learning.

Chapter three

Chapter three looks at the theoretical underpinning of continuous professional development and ICT integration. The theories that underpin the study are the Technological Pedagogical and Content Knowledge (TPACK) framework, the SAMR framework as well as social constructivism.

Chapter four

Chapter four outlined the research methodology used in the study. This chapter looks at research methodology, research setting and research design which is Mixed Method Case Study Research (MMCSR) and research paradigm and research assumptions. This chapter also looks at all things related to how the data was collected. Therefore, this chapter outlined the data collection methods tools, sample and how data was analyzed. This chapter also outlined the issues of reliability and validity and how was maintained in this study and the ethical considerations (how the researcher remained ethical and the permissions that need to be given).

Chapter five

Chapter five gives an overview of the data that was collected. Using an inductive approach to thematic analysis, this chapter will analyse the data using both qualitative and quantitative measures according to central themes that came from the data collected.

Chapter six

Chapter six discusses the data that was analyzed in the previous chapter. The researcher will discuss the data and all patterns and significances that was picked up which speak to the research questions. This chapter draws the thesis to a close by answering the research questions, highlighting the strengths and limitations of the study, giving recommendations and a conclusion.

1.8) Summary

This chapter gives an overview of the research study . The researchers background and motivation for doing the study was discussed. The researcher stated the research objectives and research questions that will be explored in this study. The significance of the study was discussed. Lastly, the researcher outlined what is to be expected in each chapter of this thesis.

Chapter Two
Literature review

2.1) Introduction

The topic of this study looked at continuous teacher professional development with regards to ICT integration in mathematics education and sought to investigate the effects this ICT teacher professional development has on the integration of ICT in Foundation Phase mathematics teaching and learning. This literature review looked at the broader literature and then draws in narrower and speaks to the topic of this study. The following literature was discussed under the following headings; ICT in education which looks at the first introduction of technology into education as well as the further integration of ICT into education and the integration of ICT into Foundation Phase mathematics education. The following heading that was discussed is continuous professional development, what it is and what it entails.

This chapter also sheds light on continuous professional development programmes that focus on ICT integration both globally and locally as well as online CPD programmes offered to teachers. Another heading that was discussed is continuous professional development in the integration of ICT into the Foundation Phase mathematics classroom as well as the ICT tools and applications for teaching and learning.

2.2) ICT in education

2.2.1) The introduction of technology into education

Educational technology is defined by Lathan (2022) as "the technological tools and media that assist in the communication of knowledge, and its development and exchange". The rise of the use of technology in schools began in the early 1980s when "computers in education started to become popular in educational policy-making" (Pelgrum & Law, 2003, p. 19). "Later, near the end of the 1980s, the term 'computers' was replaced by 'IT' (information technology), signifying a shift of focus from computing technology to the capacity to store and retrieve information. This was followed by the introduction of the term 'ICT' (information and communication technologies) around 1992, when e- mail started to become available to the general public" (Pelgrum & Law, 2003, p. 19). The introduction of ICT into education "brings a new paradigm in education in various aspects especially in mathematics teaching and learning, among others are the change from traditional learning to new learning, information delivery to information exchange and teacher-centred to student-centred" (Alcantara, Veriña,

& Niem, 2020, p.27).

ICT (Information and Communications Technology) is defined as a "diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information" (Tinio, 2003, p. 4). ICT "refers to technologies that provide access to information through telecommunication" (Ratheeswari, 2018, p. 45), primarily focusing on communication technologies including the internet, cellphones, and other forms of communication mediums (Ratheeswari, 2018). "ICT literacy is using digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (Panel, 2002, p. 2) meaning ICT's are considered skills for life rather than merely just software systems and applications (Adesote & Fatoki, 2013). Thus, ICT as a "skill for life" was introduced into the curriculum at schools in developing nations. (Adesote & Fatoki, 2013).

2.2.2) The integration of ICT into education

Globally the introduction of ICT into schools often started with the rationale that learners needed to learn how to use ICT and to develop 21st century skills (Ford & Botha, 2010). 21st century skills in education go beyond reading and writing (Geisinger, 2016), and focuses on skills such as intrapersonal, cognitive, interpersonal, and technical skills (Ananiadou & Claro, 2009). In order to meet the demands of the 21st century, it is necessary for new and innovative skills of communication, technology and collaborative practices to be introduced into education and the workplace "Meeting the demands of education, work, and commerce in the 21st century necessitates additional layers for communication skills, technological savvy, a global view, collaborative practices, digital skills, and more innovative applications" (Geisinger, 2016). However, since the introduction of ICT into schools, the focus is now changing to ICT becoming a tool for teaching and learning (Ford & Botha, 2010). Integration of ICT into teaching and learning is not a method but a medium in which a variety of methods, approaches and pedagogical philosophies may be implemented (Salehi & Salehi, 2012).

Modern technology offers many means of improving teaching and learning in the classroom (Lefebvre, Deaudelin & Loiselle, 2006). Globally many countries (especially developed countries) have integrated modern technology into their curriculum. According to Pulkkinen (2007), over the past two decades ICT integration has been one of the leading aspects in

educational development in developing countries such as European countries.

Globally, programmes such as Google classroom were invented in 2014 as a new tool to be used in education (Shaharanee, Jamil & Rodzi, 2016). “This classroom facilitates the teachers to create and organize assignments quickly, provide feedback efficiently, and communicate with their classes with ease” (Shaharanee, Jamil & Rodzi 2016, p. 5). In 2007, the Australian government implemented a policy called the Digital Education Revolution (DER) (Albion, Tondeur, Forkosh-Baruch & Peeraer (2015). The policy “was intended to ensure that all students would complete schooling with knowledge and skills for using ICT in employment, and that learning across the curriculum would be enhanced by the application of ICT” (Albion, Tondeur, Forkosh-Baruch & Peeraer (2015, p. 660). Along with the policy came a project to upskill both teachers and pre-service teachers’ professional development (DEEWR, 2010). Hence projects like the Teaching Teachers for the Future (TTF) project were introduced across Australian institutions aimed at developing pre-service teachers to be competent in ICT integration before they become teachers (Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015).

Locally, in South Africa in 2003 the minister of Education drafted an e-Education white paper which set out the intention of e-Education and the goals of the DBE. “Every South African learner in the general and further education and training bands will be ICT capable (that is, use ICT confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community) by 2013.” (Department of Education, 2003). It has been nine years since the target date, and this has not been achieved. However, there has been programmes and projects run over the years to develop ICT in schools. In response to what the minister has set out, “the Gauteng Department of Education (GDE), as well as the Western Cape Education Department (WCED), launched various ICT initiatives known as paperless or smart-classrooms in their provinces” (Saal, Graham & Van Ryneveld, 2020, p. 253-254). These initiatives were mainly aimed at disadvantaged schools equipping them with technological devices such as smartboards and tablets (Gina & Kubayi, 2016).

2.2.3) ICT integration in Foundation Phase mathematics education

Various studies have shown the benefits of integrating ICT into mathematics education. Integrating technologies into mathematics education can provide learners with representational resources and linking mechanisms that can support learners complex mathematical ideas

(Moreno-Armella, Hegedus, & Kaput, 2008). Integrative teaching methods can motivate and support independent learning (Baya'a, & Daher, 2013). These rich and interconnected representations encourage active participation in the discovery of mathematics concepts and topics that helps foster a deeper understanding of the mathematical ideas (Alcantara, Veriña, & Niem, 2020) (Kaput, Hegedus, & Lesh, 2020). After about two decades of research already done on the potential of integrating technology into mathematics education (Drijvers, 2015), the National Council of Teachers of Mathematics (NCTM) stated the following: "Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology" (National Council of Teachers of Mathematics [NCTM], 2008). There are various software programmes designed to aid teaching and learning such as Geogebra and MathLab (Pannen, 2015). Pannen (2015) also lists online programmes which teachers and learners can download and use in the own time and pace to aid teaching and learning such as Khan Academy and YouTube (Pannen, 2015).

There are several benefits to using technology in mathematics education for example it can aid problem solving, practicing number skills, and exploring patterns and relationships (Sivakova, Kochoska, Ristevska, & Gramatkovski, 2017). ICT can be used in various forms in mathematics education (Das, 2019) such as spreadsheets, databases, graphic calculators, online and interactive resources (Sivakova, Kochoska, Ristevska, & Gramatkovski, 2017). Das (2019) posits that through the use of ICT, learners are taught to work collaboratively and develop their problem-solving skills using technology. (Das, 2019,). Sivakova, Kochoska, Ristevska, & Gramatkovski (2017) listed five major opportunities for children to use ICT in mathematics learning namely, "learning from feedback; observing patterns and seeing connections; exploring data; teaching the computer, and developing visual imagery" (Sivakova, Kochoska, Ristevska, & Gramatkovski, 2017, p.470).

Weigand & Bichler (2010) highlight the fact that only providing ICT resources to schools is not sufficient for successful ICT integration (Weigand, & Bichler, 2010). Adequate teacher training is necessary to develop teachers and encourages a 'buy-in' from teachers to integrate technology into classroom practice (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010) and thus the CPTD programmes need to be looked at.

2.3) Continuous professional development (CPD)

Continuous professional development (CPD) "refers to any activities aimed at enhancing the knowledge and skills of teachers by means of orientation, training and support" (Coetzer, 2001, p. 78). "Well-structured CPD can lead to successful changes in teachers' practice, school improvement and improvements in pupils' achievement" (Bolam and Weindling 2006, p. 113). Since education is everchanging, CPD "is essential for upgrading and updating teachers because the rate of social and educational change makes pre-service training an inadequate basis for long term professional competence" (Luneta, 2012, p. 360). "Effective PD experiences are designed to help teachers build new understandings of teaching and learning through direct experiences with strategies that help students learn in new ways" (Lee, 2001, p. 2). "Teaching nowadays requires every educator to equip themselves with up to date teaching strategies, teaching competencies, incorporate contemporary teaching strategies, and become apprised of advancements in subject knowledge" (Ibrahim, Norman, Nordin & Mazin, 2020, p. 1).

Since the introduction of 21st century skills in education, it has become a challenge for many teachers to have to cope with learners new needs and demands with regard to 21st century learning (Ibrahim, Norman, Nordin & Mazin, 2020). Therefore, Ibrahim, Norman, Nordin & Mazin (2020) posit that "it is necessary to design extensive CPD programs, which include the use of successful strategies to reach the ultimate goal of CPD" (Ibrahim, Norman, Nordin & Mazin, 2020, p. 1). According to Al-Madani & Allaafiajiy (2014) for ICT to be successfully integrated into the teaching and learning process, it requires teachers' skills, knowledge, and confidence in ICT to be developed (Al-Madani & Allaafiajiy, 2014). Although access to ICT resources play a role in whether schools are integrating ICT into education, the key to incorporating ICT into education are the teachers (Kadel, 2005) therefore, teachers must be competent and skilled enough (Kadel, 2005); furthermore , the notion that teachers are to be considered the most crucial player in educational change is not surprising (Hermans, Tondeur, Van Braak, & Valcke, 2008).

2.4) Continuous professional development programmes

2.4.1) ICT continuous professional development programmes globally

There have been various CPD programmes to upskill teachers in ICT globally. The Vital programme established in England is a CPD programme aimed at helping teachers use ICT to enrich their lessons and find new ways to engage learners (Bradshaw, Twining & Walsh, 2012).

There has also been CPD programmes focusing on pre-service teachers at higher education institutions. The Teaching Teachers for the Future (TTF) programme, which centers around pre-service teachers was aimed at revitalizing teacher preparation to enhance teaching and learning with ICT at several Australian teacher education institutions (TEI) (Albion, Tondeur, Forkosh-Baruch & Peeraer, 2015). When it comes to CPD focusing on ICT integration in mathematics, countries like Latvia created a programme for mathematics and science teachers. Between 2006 and 2011 mathematics and science teachers attended CPD training programmes on ICT integration in the classroom.

2.4.2) ICT continuous professional development programmes on the African continent

On the African continent, CPD programmes such as the World Links programme in Ghana and Uganda, and the Connectivity for Educator Development programme in Uganda are examples of successful professional development programmes (Hennessy, Harrison & Wamakote, 2010). These programmes focus more on "helping teachers to use technology as a tool, and to transform their classrooms into interactive learning environment" (Hennessy, Harrison & Wamakote, 2010, p. 46). Locally, in South Africa, the Information Communication and Technology for Rural Education Development (ICT4RED) programme was created as part of the "Technology for Rural Education Development (TECH4RED) research programme, which aims to contribute to the improvement of rural education via technology-led innovation" (Botha & Herselman, 2015, p.1). The programme, which was carried out in the Eastern Cape involved distributing tablets to twenty-six rural schools (Botha & Herselman, 2015). The professional development component of this programme aimed at meeting teachers at their level of ICT knowledge and scaffolding those teachers' skills and understanding of ICT integration to reflect 21st century teaching and learning (Botha & Herselman, 2015).

In the Western Cape, the Cape Teaching and Leadership Institute (CTLI) provides various ICT courses and professional development programmes to upskill teachers on ICT integrated teaching and learning (WCED, 2021). The main aim of the Cape Teaching and Leadership Institute (CTLI), which falls under the WCED directorate, is to enhance the professional development of teachers to enable them to manage and implement the curriculum (Mettler, 2016). As stated in the *Guidelines for Teacher Training and Professional Development in ICT*, CPTD "programmes should be subject-specific and relevant to the learning areas" (Hindle, 2007, p. 4). Therefore, CTLI offers various ICT integration courses that are phase and/or

subject specific such as the ICT Integration course for the Foundation Phase and an ICT Integration course for High School Language teachers, as well as courses for school managers such as an ICT course for principals (WCED, 2021).

2.4.3) Online ICT continuous professional development programmes

When discussing teacher professional development of ICT integration, we cannot neglect the online training programmes that are taking place to upskill teachers especially in the current pandemic where many opt for a virtual meeting. Both global, national and local bodies have developed online courses for teachers on ICT integration. In 2007, Microsoft developed a programme that was implemented worldwide called the Innovative Schools Programme (ISP), "that sought to support teachers around the world as they transformed traditional schools into providers of innovative learning experiences, that prepare students for the 21st century" (Butler, Leahy, Hallissy & Brown, 2016). Since then, Microsoft has had a range of online courses to upskill teachers on ICT integration called Microsoft Educator Center, one of which is the 21st Century Learning Design (21CLD) courses aimed at developing teachers' knowledge and skill of ICT's in the classroom in all subjects and learning areas. The 21CLD course "provides a rationale for the need to develop 21st century skills among our students. It presents the key 21st century skills of collaboration, knowledge construction, self-regulation, problem-solving and innovation, information and communications technology (ICT) for learning, skilled communication" (Microsoft, 2021). The Google for Education Teacher Center offers courses such as the *Learn the basics of Google Workspace for Education* programme, courses on Google suites including Google Classroom as well as providing teachers with the opportunity to become a Google certified educator.

Locally, CTLI has offered many online training programmes for all school stakeholders such as ICT integration courses (Western Cape Education Department, 2021). Online platforms such as Google and Microsoft have created online programmes for teacher professional development when it comes to classroom ICT integration. This year CTLI had ICT courses namely 'Google Essentials for Teachers' which introduces "teachers to Google Workplace Apps as tools to use in both virtual and traditional classroom spaces" (Cape Teaching and Leadership Institute, 2022) as well as Microsoft Essentials for Teachers which deals with Microsoft Office and introduces "teachers to Office 365 Apps as tools to use in both virtual and traditional classroom space" (Cape Teaching and Leadership Institute, 2022).

2.5) Continuous professional development in the integration of ICT into mathematics teaching and learning

Since the rise of technology in education, it has become a vital tool in Mathematics education today (Niess, 2006). The use of technology in education can aid mathematical understanding, reasoning, problem solving and mathematical proofs (NRC, 2000). "ICT improves the way mathematics should be taught and enhances student understanding of basic concepts" (Keong, Horani & Daniel, 2005) and is essential for Mathematics teaching and learning (Ittigson & Zewe, 2003). Becta (2003) stated key benefits to using ICT in Mathematics teaching and learning (Keong, Horani & Daniel (2005). One of the benefits stated by Becta (2003) was that the use of technology in Mathematics "supports constructivist pedagogy, wherein students use technology to explore and reach an understanding of mathematical concepts" (Becta, 2003 as cited in Keong, Horani & Daniel, 2005, p. 43). Therefore, it develops problem solving and higher order thinking skills in mathematical acquisition (Becta, 2003). Clarke (2006) opined that ICT is in line with numeracy and literacy as a skill that every person needs to be confidently possess in a modern society (Clarke, 2006).

Looking at CPD with regards to ICT integration in Mathematics teaching and learning, Niess, Lee and Kajder (in press) identified key areas which teachers must prepare for when it comes to integrating ICT into the teaching and learning of Mathematics. These key areas are curricular, instructional, and learning needs in mathematics in the 21st century. The second key area looks at the unique capabilities of each of the new instructional tools, learner knowledge, access, and management concerns. Another key area was the evaluation and assessment of learners with the new ICT tools. However, in many South African schools, teachers are still assessing as if technology does not exist, using the traditional method of assessment (Naudé & Davin, 2017). There are many factors that influence lack of e-assessment done in South African schools including lack of access to resources, professional development, and teacher training (Naudé & Davin, 2017, p.193). Jaworski and Huang (2014) suggested that in order for a CPD programme to be effective it must include the following: aligned goals between all stakeholders (school, district, and state), a focus on core content, the modelling of teaching strategies, opportunities for active learning, teacher collaboration and continuous feedback and follow-up (Jaworski and Huang, 2014). In Latvia between 2005 and 2011, a programme was created for mathematics and science teachers in both primary and high school. The programme centered around ICT integration in the classroom (Anderson, 2016). In Malaysia, CPD were designed

for both pre-service and in-service teachers.

2.6) ICT tools and applications used for teaching and learning

2.6.1) ICT tools

Since the introduction of ICT into the classroom, there has been many ICT tools and application that has been used to enhance teaching and learning. ICT is not one single tool or application but rather it encompasses a range of evolving technologies that include "a combination of hardware, software, multimedia, and delivery systems" (Das, 2019, p.21). One of the first ICT tools in mathematics teaching and learning was the graphic calculator and overhead projectors (Goos, Galbraith, Renshaw & Geiger, 2001). "Some examples of the use of ICT in maths are portable, graphic calculators, computerized graphing, specialized software, spreadsheets, and databases" (Das, 2019, p.23). Primarily used in the higher grades these tools assist in calculating and problem-solving which is key in mathematics (Das, 2019). "A wide range of information and communication technology (ICT) is available in most primary schools as useful resources and tools to support the teaching and learning of mathematics. This can include programmable robots, calculators, television, radio, audio tape, video, digital cameras as well as computers, software, access to the internet and interactive whiteboards (IWBs)" (Richards, 2005, p.23).

Since then, there has been many tools used in the classroom such as computers, laptops, tablets, televisions, cell phones, LCD (Liquid Crystal Display) projectors, and interactive whiteboards to name a few. Many schools globally are equipped with computer labs where learners can interact with one another and the internet (Campbell & Pargas, 2003). Schools have even moved away from the computers to wireless tools such as the laptop and tablets that has been built into school libraries and classrooms (Campbell & Pargas, 2003). The use of these wireless tools like laptops can be used in various ways such as for administrative tasks, a learning tool, preparation and instructional delivery and management (Inan & Lowther, 2010). The 21st century learner has access to and knowledge of a cellphone but instead of using this as merely a social tool, (Clayton & Murphy (2016) suggests that this digital device can also be a "powerful resource for learning" (Clayton & Murphy, 2016, p.99). Cellphones have been accepted in various schools as a learning tool. "Since nearly 88% of high school students ages 13-17 have access to a mobile phone, schools are shifting their mobile phone use policies to adapt to today's learners (Horrigan 2015)" (Clayton & Murphy, 2016, p.99).

Interactive Whiteboard (IWB) has become popular in many schools over recent years (Beauchamp, 2004). The interactive whiteboard is a device that interfaces with a computer, these were designed to increase learner interaction since the boards are interactive and allow learners to come up and work on the board (Robinson, 2004). Using the IWB the teacher can interact with graphs in the mathematics classroom (Robinson, 2004). "The IWB is here regarded as any board connected to a PC, capable of displaying a projected image which allows the user to control the PC by touching the board or with the computer mouse" (Beauchamp, 2004, p.328). Since the invention of these boards there has been many companies that created their own brand of the interactive whiteboard for example the SmartBoard was produced by SMART Technologies, Inc (Robinson, 2004).

2.6.2) ICT applications

Just like the ICT tools, there are many ICT educational applications that can be used for teaching and learning. Educational applications like YouTube, Edmodo and Microsoft are popular when teaching mathematics in the classroom. Over the past few years, YouTube has increasingly become popular for educational purposes and when used in mathematics it can be used in critical thinking, mental activities and problem solving (Nacak, Bağlama & Demir, 2020)."YouTube is used by educators as a pedagogical resource which aims to teach new knowledge and skills through videos (Prabhu, Vorne, Glaser, Rajagopalan, & Beriwal, 2017)" (Nacak, Bağlama & Demir, 2020, p.2). Programmes like Math & Learning Videos 4 Kids, Eddie Woo (Mister WooTube) and Mathantics are YouTube channels designed for mathematics education in primary school (Roberts, 2021). Edmodo is an online app that look similar to the popular app Facebook, teachers are at the centre of this app, and it can be used to set task, send homework and get learner feedback and responses in real time. Learners can also interact and see one each other's posts (Muanifah, Widodo, & Ardiyaningrum, 2019). TouchCounts, an educational app available on the iPad is designed to develop young children's counting and arithmetic (Larkin & Calder, 2016).

2.7) Summary

This chapter reviewed the literature on the integration of ICT's into Foundation Phase mathematics and the CPD programmes offered to teachers to assist with this integration. The

literature looked at what ICT's are, what ICT tools and applications are available for mathematics teaching and learning are and how ICT was first integrated into education. The literature describes what CPD is and looks at the various CPD programmes both globally, locally, and online. Globally and locally, there are several initiatives to train teachers on ICT integration as well as training pre-service teachers. The online ICT programmes allow teachers to access course virtually and these programmes can reach more teachers. Chapter three discusses the theoretical frameworks that underpin this study.

Chapter Three

Theoretical conceptual framework

3.1) Introduction

This chapter outlines the theories that underpin the framework for this research study which are the Technological Pedagogical and Content Knowledge (TPACK) framework, the SAMR framework as well as social constructivism. The TPACK framework draws on Mishra & Koehler (2006) TPACK framework which looks at Technological Pedagogical Content Knowledge and how these terms intertwin to create effective integration of ICT into teaching and learning. The SAMR framework created by Ruben Puentedura is a model based on the integration of ICT's into the classroom and looks at the various levels of integration. Social constructivism will be discussed in this chapter because this theory underpins this study. Lev Vygotsky's framework on social constructivism speaks to the need for teaching and learning to be done through social interaction and collaboration. This speaks to the topic of this study since teaching with ICT's involves collaboration as collaboration is one of the key points to 21st century learning.

3.2) Technological Pedagogical And Content Knowledge framework (TPACK)

The theoretical underpinning of the study is based on the TPACK framework. The TPACK model combines three main components of learning namely, technology, pedagogy, and content (Mishra and Koehler, 2006). The TPACK framework "considers the role of technology in teaching" (Swallow & Olofson, 2017, p. 228). This framework builds on Shulman's (1986) "construct of Pedagogical Content Knowledge (PCK) to include technology knowledge" (Koehler & Mishra, 2009:60). "We introduce the Technological Pedagogical Content Knowledge (TPACK) as a way of thinking about the knowledge teachers need to understand to integrate technology effectively in their classrooms" (Mishra & Koehler, 2008, p. 2). The TPACK model takes curriculum content and specific pedagogical approaches and connects it to technology and "describes how teachers' understandings of these three knowledge bases can interact with one another to produce effective discipline-based teaching with educational technologies" (Koehler, Shin & Mishra, 2012, p. 17).

With Mishra and Koehler (2006) addition of technology to the PCK model, the TPACK model incorporated four new components (Swallow & Olofson, 2017) namely, technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006 as cited in Swallow & Olofson, 2017). The TPACK framework integrates the individual components by intersecting them. Mishra & Koehler (2008) argue that "teachers who have this type of understanding are characterized by the creative, flexible, and adaptive ways in which they navigate the constraints, affordances, and interactions within TPACK framework" (Mishra & Koehler, 2008, p. 2), and that at the centre of good ICT integrated teaching are the three components of technology, pedagogy, and content (Mishra & Koehler, 2008). According to several studies, the interaction between these individual knowledge components are equally important (Mishra & Koehler, 2008), and in order for teachers to successfully integrate technology into teaching, it is critical that they use an interaction of the different knowledge components (Mishra & Koehler, 2008) (Swallow & Olofson, 2017) (Koehler & Mishra, 2009).

Figure 1 below (taken from Koehler & Mishra, 2009) illustrates the three core knowledge components that make up the TPACK model: technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). The diagram shows how these components intersect to form the bodies of knowledge: technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK) and technological pedagogical and content knowledge (TPACK).

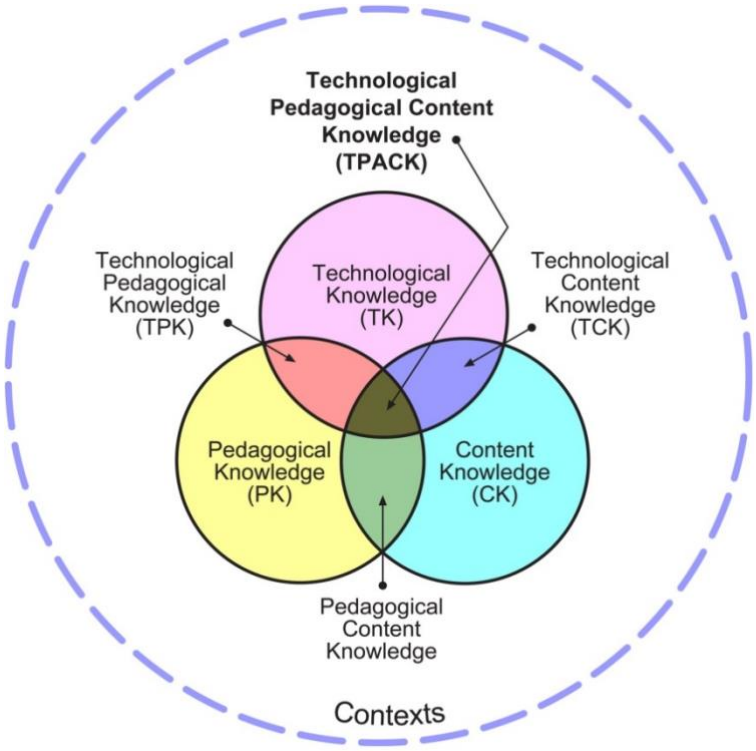

Figure 1:Model of The TPACK framework and its knowledge components

[Taken from (Koehler & Mishra, 2009)]

Technological knowledge (TK) is described by Mishra & Koehler (2008) as knowledge of various technologies such as books, chalk, the internet, and other classroom tools used for lessons. It involves the knowledge and skills teachers possess to use their tools and software such as using an interactive whiteboard or web browser (Mishra & Koehler, 2008). Pedagogical knowledge (PK) is the knowledge of teaching and learning and encompasses all aspects involving pedagogy such as classroom management, teaching methods, lesson planning and assessment (Koehler & Mishra, 2009). "A teacher with deep pedagogical knowledge understands how students construct knowledge and acquire skills; develop habits of mind and positive dispositions towards learning" (Mishra & Koehler, 2008, p. 6). Content knowledge (CK) involves the curriculum and subject-matter that is being taught (Mishra & Koehler, 2008). A teacher must understand the subject content and the history and reason behind the subject-matter in order to successful convey that knowledge onto the learners (Mishra & Koehler, 2008).

Technological content knowledge (TCK) involves the understanding of how technology impacts on the curriculum content and whether teachers are using the correct ICT's to enhance learning (Mishra & Koehler, 2008). Pedagogical content knowledge (PCK) is

similar to Shulman (1986, 1987) research on PCK. PCK involves all aspects of assessment, teaching, learning and curriculum (Koehler, Mishra & Cain, 2013). Technological pedagogical knowledge (TPK) is an understanding of how teaching and learning changes with the integration of technology. Technological pedagogical and content knowledge (TPACK) incorporates all components of knowledge: technology, pedagogy, and content (Mishra & Koehler, 2008). "TPACK is an emergent form of knowledge that goes beyond all three "core" components (content, pedagogy, and technology)" (Koehler & Mishra, 2009, p. 66). Mishra & Koehler (2009) argue that the TPACK framework is the basis for effective teaching with technology (Koehler & Mishra, 2009).

If implemented correctly, the TPACK framework should form the basis of teacher education and teacher professional development (Koehler & Mishra, 2009). Hence, the decision to use this framework as the theoretical underpinning of my study. The TPACK model can help to evaluate the CPD programmes that was used to upskill teachers and determine whether both the programme and the implementation of ICT integration in the classroom follows the TPACK model.

3.3) SAMR Framework

The Substitution Augmentation Modification Redefinition (SAMR) framework developed by Ruben Puentedura is "based on a model of integrating educational technology into the classroom (Tsybulsky, & Levin, 2016). SAMR shows how teachers can increase technology use in their classrooms (Ayu, Jufriadi, Mustika, Kurniawati, Pratiwi, Sundaygara, & Hudha, 2021). This framework not only provides teachers with an opportunity to increase emerging technologies in the classroom (Hilton, 2016) but also has the ability to impact learners thinking by improving their thinking skills (Ayu, Jufriadi, Mustika, Kurniawati, Pratiwi, Sundaygara, & Hudha, 2021) and by guiding learners to think differently when working in an ICT equipped environment (Kihoza, Zlotnikova, Bada, & Kalegele, 2016). The model offers a method of seeing how computer technology might impact teaching and learning by outlining a progression that educators follow in their journey towards redefining teaching and learning with technology (Kihoza, Zlotnikova, Bada, & Kalegele, 2016).

This model consists of four levels for technology use in education namely, Substitution, Augmentation, Modification and Redefinition (Romrell, Kidder, & Wood, 2014). These

levels are grouped under two different areas, Enhancement and Transformation (Hilton, 2016). "Within the SAMR model constructs, Substitution and Augmentation, represent technology usage that enhance effectiveness on existing non-digital resources whereas the Modification and Redefinition constructs describe when a technology or application leads to transformation" (Kihoza, Zlotnikova, Bada, & Kalegele, 2016, p.111).

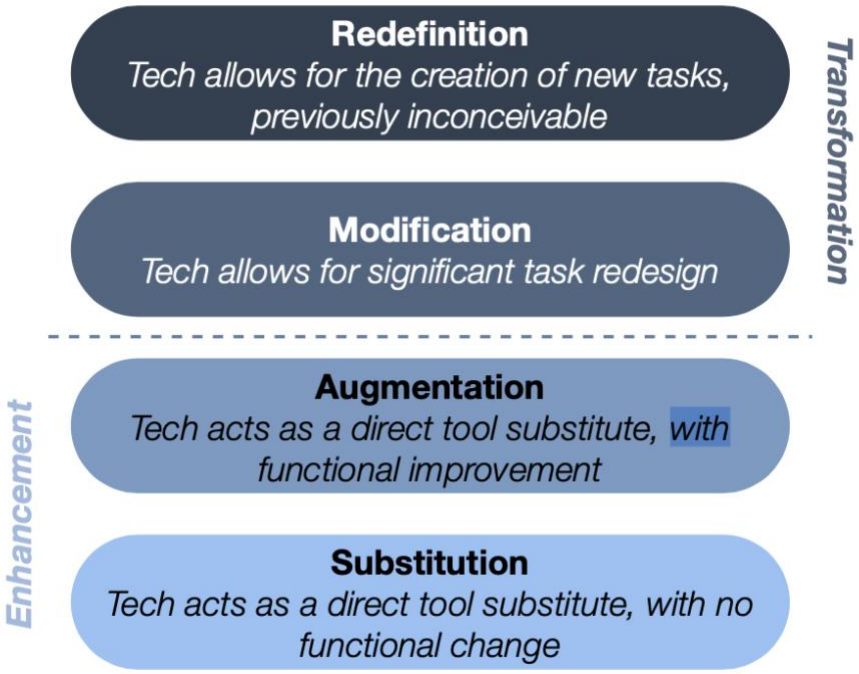

Figure 2: The SAMR framework

[Taken from (Puentedura, 2013)]

Figure 2 above shows the four levels of the SAMR framework. The bottom two levels (Substitution and Augmentation) are grouped under Enhancement because they are used to replace or improve existing tools in learning tasks (Hilton, 2016) whereas the top two levels are grouped under Transformation because they "provide new opportunities for learning that are not easily possible without technology" (Hilton, 2016, p.69). The first level of the SAMR framework is Substitution, this is where the traditional methods and tools are replaced with technology for example instead of bringing a poster to class, a PowerPoint is made (Kihoza, Zlotnikova, Bada, & Kalegele, 2016). These tasks can however be completed without technology as technology is merely used as a replacement (Hilton, 2016). Similar to Substitution, Augmentation is also a replacement of the traditional tools to a task that can be

completed without technology (Hilton, 2016). However, unlike Substitution, through Augmentation there are functional improvements (Puentedura, 2013), learners can complete tasks in a more effective and informative way (Nair, & Chuan, 2021).

Unlike the first two levels, Modification is not possible without technology, the pre-existing task is significantly altered using technology (Hilton, 2016). The syllabus remains the same, but the teaching methods are changed so learners can accomplish what they could not before the use of technology (Nair, & Chuan, 2021). Redefinition allows for the teacher to create new tasks that were not possible before the use of technology (Hilton, 2016). This level allows the teacher to replace the traditional methods with new and effective methods to gain learners interest through the use of technology (Nair, & Chuan, 2021). "Although visually organised in a ladder form, the SAMR model is not essentially hierarchical. The levels do not prescribe a movement from the lower level to the upper one but rather the choice of a level most relevant to the task" (Drugova, Zhuravleva, Aiusheeva, & Grits, 2021, p.4928).

3.4) The TPACK and SAMR frameworks

Both the TPACK and SAMR frameworks are concerned with the integration of technology into the classroom (Kihoza, Zlotnikova, Bada, & Kalegele, 2016). The TPACK framework looks at the role of technology in teaching (Swallow & Olofson, 2017) and how teachers knowledge of integrating technology is used to create an effective classroom (Mishra & Koehler, 2008). This framework has three core knowledge components, technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). The diagram in figure 1 shows how these components intersect to form the bodies of knowledge: technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK) and technological pedagogical and content knowledge (TPACK) (Koehler & Mishra, 2009).

The SAMR model looks at how teachers can integrate technology into their classrooms through four levels, Substitution, Augmentation, Modification and Redefinition (Hilton, 2016). "The SAMR model stands on the theory that classroom technology integration is fabricated on the transformation or enhancement of traditional pedagogies to the use of new efficient technologies, either through the substitution, augmentation, modification or redefinition of educational tasks" (Kihoza, Zlotnikova, Bada, & Kalegele, 2016, p.111).

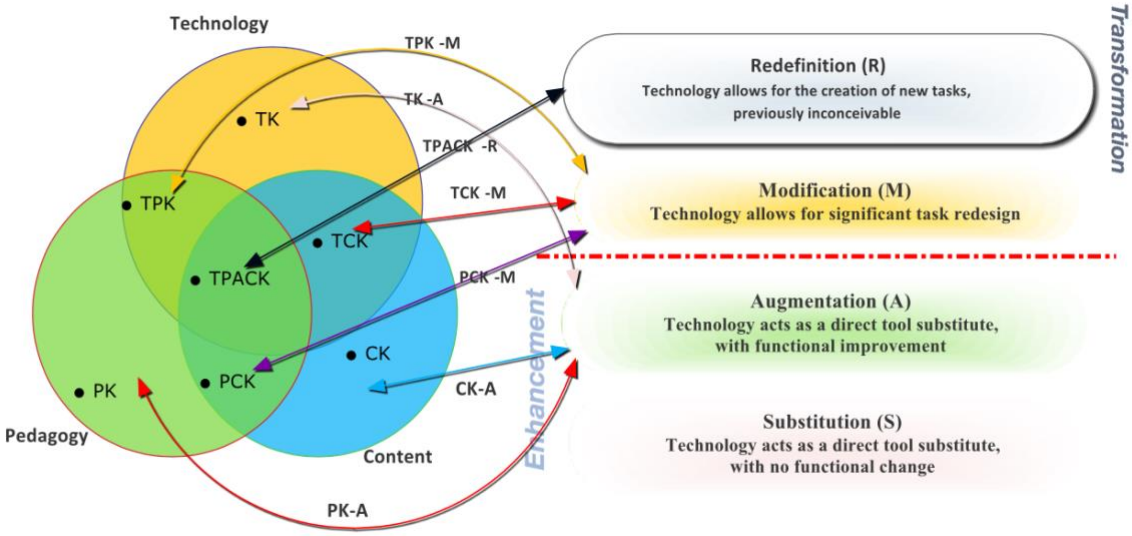

Figure 3: TPACK and SAMR frameworks correlation

[Taken from (Kihoza, Zlotnikova, Bada, & Kalegele, 2016)]

Figure 3 above shows the correlation between the two frameworks. Kihoza, Zlotnikova, Bada, & Kalegele (2016) describe how these frameworks are linked, the Technological Pedagogical Knowledge and Modification (TPK-M), Technological Knowledge and Augmentation (TK-A), Technological Content Knowledge and Modification (TCK-M), Pedagogical Content Knowledge and Modification (PCK-M), Content Knowledge and Augmentation (CK-A), Pedagogical Knowledge and Augmentation (PK-A) and Technological Pedagogical And Content Knowledge and Redefinition (TPACK-R) (Kihoza, Zlotnikova, Bada, & Kalegele, 2016, p.113). According to Drugova, Zhuravleva, Aiusheeva, & Grits (2021) combining these two frameworks can reinforce one another and "provide valuable insight into where challenges emerge and opportunities exist when choosing technologies for student learning. TPACK helps to contextualise the teacher knowledge required for technology integration. SAMR assists in analysing the specific levels used for enhancement and transformation and presents an opportunity to examine the integration from both the teachers' and students' perspectives" (Drugova, Zhuravleva, Aiusheeva, & Grits, 2021, p.4928).

3.5) Social constructivism

3.5.1) Social constructivism

Propounded by Lev Vygotsky, “Social constructivism is a theory of knowledge in sociology and communication theory that examines the knowledge and understandings of the world that are developed jointly by individuals” (Amineh & Asl, 2015, p.13). “Social constructivists believe that individuals seek understanding of the world in which they live and work” (Creswell & Creswell, 2017, p.8). “This theory assumes that understanding, significance, and meaning are developed in coordination with other human beings. The most important elements in this theory are (a) the assumption that human beings rationalize their experience by creating a model of the social world and the way that it functions and, (b) the belief in language as the most essential system through which humans construct reality (Leeds-Hurwitz, 2009)” (Amineh & Asl, 2015, p.13).

Since social interaction and collaboration are at the heart of social constructivism, it proves to be a highly effective method of teaching that all learners can benefit from (Kalina & Powell, 2009). Vygotsky believed that social interaction “was an integral part of learning” (Kalina & Powell, 2009, p.243). “Social constructivism is based on the social interactions a student in the classroom along with a personal critical thinking process” (Kalina & Powell, 2009, p. 243). “In contrast to cognitive-constructivism, ‘social constructivism’ emphasizes ‘collective-Learning’ where the role of teachers, parents, peers and other community members in helping learners becomes prominent. Social constructivists emphasize that learning is active, contextual and social, therefore the best method is ‘group-learning’ where teacher is a facilitator and guide (Tinio, 2002)” (Allah & Ghulam, 2010, p.32).

Kalina & Powell (2009) outline the methods for an effective social constructivist classroom. The classroom environment needs to be open and characterized by engagement, when students are not engaged, an ineffective classroom can be subjected to disruptive students, and learning will not occur (Kalina & Powell, 2009, p. 248). “The components of a constructivist environment include providing means for students to experience real world or meaningful practices. Students learn through examples that they can relate to on an emotional, or on a cognitive basis. Students can experience their world using meaningful practices that connect emotional or affective, as well as thinking or cognitive parts of self. For example, students who write essays could select their own topics corresponding to their

reading assignments so that creative expression can follow" (Kalina & Powell, 2009, p. 248).

3.5.2) Using ICT in a social constructivist environment

As mentioned above social constructivism is rooted in social interaction and collaborative learning (Kalina & Powell, 2009). Silin & Kwok (2017) posit that "the use of ICT supports collaborative learning, knowledge construction and critical thinking, participation and diversifying of ideas, scaffolding of concepts and self-reflection among students in a PBL" (Problem-Based Learning) environment (Silin & Kwok, 2017, p. 51) and thus we see that the integration of ICT's into the classroom supports a social constructivists approach to teaching and learning. "In social constructivists' perspective, classroom teaching is supported and facilitated by technology especially the telecommunication tools (Mumtaz, 2006). These tools provide student with opportunities for interactivity, a process of social learning. In this regard, Vygotsky believes that "the classroom should provide variety of learning materials (including electronic)" (Jha, 2017, p.66). Social constructivists explain the technology-adoption as a process of involving social groups into the innovation process where learning takes place on the learners' experiences, knowledge, habits, and preferences (Bondarouk, 2006). In contrast to traditional classrooms where teachers used a linear model and one-way communication, the modern learning is becoming more personalized, student-centric, nonlinear and learner-directed (Cagiltay et al., 2006)" (Allah & Ghulam, 2010, p.32).

Allah & Ghulam (2010) posit that there are extremes in the various learning theories for example, the behaviourist model where learners are dependent on the teacher and learning is "one-way communication and actions of teachers rather than their interaction with the students (Young, 2003)" (Allah & Ghulam, 2010, p.32). The other extreme is that of the social constructivist where learners "follow self-designed, self-controlled and socially collaborative learning-tracks (Phillips et al., 2008) (Allah & Ghulam, 2010, p.32). Allah & Ghulam (2010) suggest a "middle stage" where a mix of both learning environments are used in the classroom. "Teachers still plays the dominant role but student is given the liberty of apply his/her cognitive powers to construct knowledge along with learning from teacher" (Allah & Ghulam, 2010, p.32).

3.6) Summary

This chapter discusses the various theories that underpin this study. The TPACK framework, SAMR framework and social constructivism underpins this study. The TPACK framework looks at teachers integration of technology into their classrooms (Mishra & Koehler, 2008) and how the pedagogical knowledge (PK) and content knowledge (CK) should be integrated with the technological knowledge for successful integration of ICT into teaching and learning. Similarly, the SAMR model looks at integrating educational technology into the classroom by showing how teachers can increase technology use in their classrooms (Ayu, Jufriadi, Mustika, Kurniawati, Pratiwi, Sundaygara, & Hudha, 2021). This chapter discusses these frameworks in relation to this study as well as the theory of social constructivism and its role in an ICT integrated classroom. The next chapter will describe the research methodologies used in the study.

Chapter Four

Research methodology

4.1) Introduction

This chapter looks at the research methods behind this study. This study made use of both qualitative and quantitative methods to answer the research questions. This chapter defines both qualitative and quantitative research methods and how it is used in this study. This chapter also looks at the research setting, which is in the Western Cape, South Africa, the schools are situated in the Metro South Education District (MSED). The research design used is Mixed Method Case Study Research (MMCSR), this chapter outlines the reasons for this design choice as well as the research paradigm and assumptions made by the researcher.

This chapter looks at all elements related to the data collection process and therefore this chapter outlines the data collection methods and tools which are semi-structured interviews, classroom observations as well as an online questionnaire, the sampling will also be discussed which is Foundation Phase teachers who teach at schools under the MSED of the Western Cape Education Department (WCED). The methods used for data analysis will also be discussed as well as all measures related to validity and reliability. Finally, the issues concerning ethical considerations will be addressed.

4.2) Research methodology

"A research methodology is the path through which researchers need to conduct their research" (Sileyew, 2019). The research methodology acts as a guide to how the research is going to be conducted describing the methods used, analysis methods, tools, and limitations (Igwenagu, 2016). Sileyew (2019) posit that in this chapter, "the author outlines the research strategy, research design, research methodology, the study area, data sources such as primary data sources and secondary data, population consideration and sample size determination such as questionnaires sample size determination and workplace site exposure measurement sample determination, data collection methods like primary data collection methods" (Sileyew, 2019).Therefore, in this methodology section, the researcher will be outlining the research design, assumptions, and paradigm as well as the data collection method and various tools, the sampling techniques and how the data analysis was conducted.

To gather data for this study both quantitative and qualitative methods were used and therefore this study is a mixed method research study. Mixed method research incorporates techniques from qualitative and quantitative methods to answer research questions" (Byrne & Humble, 2007, p. 1). A mixed method involves collecting and analyzing data from both quantitative and qualitative methods in a single study in which the data is collected concurrently or sequentially (Byrne & Humble, 2007). A mixed method was chosen because this study makes use of both qualitative and quantitative tools to gather data. It is important to note that although a mixed method will be employed for this study, the study is qualitative in nature and makes use of quantitative tools for the purpose of data triangulation and to make use of the percentages, statistics and numbers gathered from the quantitative tool to help the researcher to further answer the research questions.

4.2.1) Qualitative research method

Qualitative research is used to gather an in-depth understanding of a problem rather than collecting statistics and numerical data (Bhandari, 2020). Qualitative research involves collecting data to understand concepts (Bhandari, 2020) and seeks to explain how and why "aparticular phenomenon, or behavior, operates as it does in a particular context. It can be used to generate hypotheses and theory from the data" (McLeod, 2019) and permits participants to share their experiences (Pathak, Jena & Kalra, 2013). "Qualitative method is used to understand people's beliefs, experiences, attitudes, behavior, and interactions" (Pathak, Jena & Kalra, 2013). There are many ways to gather data for a qualitative research study; interviews, focus groups, observations, and open-ended surveys (Bhandari, 2020). The data for this study was collected in the form of observations at certain schools as well as interviews with specific teachers.

4.2.2) Quantitative research method

"Quantitative research is a way to learn about a particular group of people, known as a sample population. Using scientific inquiry, quantitative research relies on data that are observed or measured to examine questions about the sample population" (Allen, 2017). "Quantitative research encompasses a range of methods concerned with the systematic investigation of social phenomena, using statistical or numerical data. Therefore, quantitative research involves measurement and assumes that the phenomenon under study

can be measured. Quantitative research sets out to gather data using measurement, to analyse this data for trends and relationships and to verify the measurements made" (Watson, 2015). "There are several types of quantitative research" (Sukamolson, 2007). Survey research was used to gather the quantitative data through a questionnaire. "Survey research uses scientific sampling and questionnaire design to measure characteristics of the population with statistical precision" (Sukamolson, 2007).

4.3) Research setting

A "research setting is the physical, social, or experimental context within which research is conducted" (Davis, 2021). A research study that involves qualitative methods needs to take into account the context in which the phenomenon is taking place (Neuman, 1994). The research was conducted with Foundation Phase teachers in the Western Cape province. Teachers were selected and asked to complete the online questionnaire. Four Foundation Phase classrooms were observed, and those teachers were interviewed. The research will be conducted in the Metropole South Education District of the Western Cape Education Department.

4.3.1) Western Cape Education Department (WCED)

The Western Cape Education Department is the education department in the Western Cape.The WCED is responsible for grades R to twelve schooling in the province. Their primary objectives are to "improve the language and mathematics skills of learners; to improve matric results; and improve access to quality education in poor communities. The WCED operates in eight Education Districts with a Head Office in Cape Town" (Western Cape Education Department, 2022). The eight districts are Metro North Education District, Metro South Education District, Metro East Education District, Metro Central Education District, Cape Winelands Education District, Eden and Central Karoo Education District, Overberg Education District and West Coast Education District (Western Cape Education Department, 2022). The minister of Education in the Western Cape is David Maynier; each district also has a director who oversees their district.

4.3.2) Metro South Education District

As mentioned above, this research will be conducted in the Metro South Education District.This district office is situated in Mitchell's Plain, Cape Town. The Metro South Education District currently has 148 public ordinary (excluding special needs schools) primary schools made up of 123 649 learners and 6346 teachers in those ordinary primary schools (Western Cape Education Department, 2022).

4.4) Research design

To gain an in-depth understanding of the topic, a mixed method case study research (MMCSR) will be used. To identify what MMCSR is, we must look at what it is individually. Firstly, a mixed method research design combines qualitative and quantitative research approaches (Cook & Kamalodeen, 2020). As mentioned previously, a mixed method involves collecting and analyzing data from both quantitative and qualitative methods in a single study in which the data is collected concurrently or sequentially (Byrne & Humble, 2007). Thus, a mixed method design was chosen for this study. There are three core mixed method designs namely,the convergent design, the explanatory design, and the exploratory design (Creswell & Creswell, 2017). For this study, a convergent mixed method design was used. In a single- phase approach both quantitative and qualitative data is collected and analyzed separately (Creswell & Creswell, 2017).

4.4.1) Case study research design

Case study research "allows for the understanding of a complex issue, which can be a single individual or a classroom of students, a programme or an incident (Zainal 2007)" as cited in Cook & Kamalodeen (2020). "Case study research aims to explore and depict a setting with a view to advancing understanding of it" (Cousin, 2005). Case study design should be used when the focus of the study is about seeking the how and the why (Yin, 2003). Baxter and Jack (2008) stated seven different types of case studies: explanatory, exploratory, descriptive, multiple-case studies, intrinsic, instrumental, and collective case studies (Baxter & Jack, 2008).When used in qualitative research, a case study (Baskarada, 2014) "enables researchers to conduct an in-depth exploration of intricate phenomena within some specific context" (Rashid,Rashid, Warraich, Sabir & Waseem, 2019). Since this study aims to investigate the effects continuous professional development programmes has on ICT

integration in the Foundation Phase mathematics classroom, four schools and teachers' will be the case and an exploratory case study will be used. According to Yin (2014) this type of case study identifies "the research questions or procedures to be used in a subsequent research study, which might or might not be a case study" (Yin, 2014, p.238). An exploratory case study sets "to explore any phenomenon in the data which serves as a point of interest to the researcher" (Zainal, 2007, p.3). In this study the point of interest that needs to be explored is ICT integration in mathematics classrooms. Therefore, a mixed method case study research (MMCSR) was used in this study.

4.4.2) Mixed Method Case Study Research (MMCSR)

The MMCSR integrates both the mixed method and the case study with the aim of amplifying the strengths of both approaches and minimize their collective weaknesses" (Cook & Kamalodeen, 2020, p.58). Creswell & Plano Clarke (2018) posit that "a mixed methods case study design is a type of mixed methods study in which the quantitative and qualitative data collection, results, and integration are used to provide in-depth evidence for a case(s) or develop cases for comparative analysis" (Creswell & Plano Clarke, 2018, p.116). According to Creswell and Plano Clarke (2018), integrating mixed method and case study research has become increasingly popular in solving complex problems in areas such as education and policymaking (Cook & Kamalodeen, 2020). There are basic variants of MMCSR (Creswell & Creswell, 2017) this study made use of an inductive approach. In an inductive approach, "the researcher collects and analyzes both quantitative and qualitative data and then forms the cases" (Creswell & Creswell, 2017, p.230). A mixed method case study design involves the use of one or more of the three core designs within the framework of a single or multiple case study design (Creswell & Creswell, 2017). As mentioned above, a convergent mixed method will be embedded into this MMCSR design. In a typical mixed method case study design, "both types of data are gathered concurrently in a convergent core design and the results are merged together to examine a case" (Creswell & Creswell, 2017, p.230). Therefore, this design was chosen because in this study both quantitative and qualitative data collection methods was used and merged together to produce the study results.

4.5) Research paradigm

According to Kuhn (1970) a research paradigm is "the set of common beliefs and agreements shared between scientist about how problems should be understood and addressed" (Kuhn, 1979). Lather (1986) believed that a research paradigm gives us an idea of the researchers' worldview, how he/she views the world. Kivunja and Kuyini (2017) posit that a research paradigm is the conceptual lens through which the researcher examines the methodological aspects of their research project to determine the research methods that was used and how the data will be analyzed" (Kivunja & Kuyini, 2017, p. 26).

When it comes to educational research, researchers propose that paradigms can be grouped into three main approaches namely, critical theory, positivist, or interpretivist paradigms (Kivunja & Kuyini, 2017) (Rehman & Alharthi, 2016). However, in mixed method research there are three possible paradigms that could underpin research namely, "a-paradigmatic stance, the multiple paradigm stance and the single paradigm stance" (Hall, 2013, p.5). For this study a single paradigm approach stance was used. In a single paradigm approach, the researcher adopts "a single paradigm that encompasses both qualitative and quantitative research methods" (Hall, 2013, p.6). Within the single paradigm approach are two paradigms namely, pragmatism and transformative approach (Hall, 2013). A pragmatic approach underpins this research study. According to Creswell and Clark (2011) pragmatism does not view truth and reality but rather accepts that there are single or multiple realities. Pragmatists believe that knowledge is socially constructed (Yefimoy, 2004) (Morgan, 2013). Therefore, a pragmatic approach was used in this study because this study is based on the classroom experiences of teachers in terms of the integration of ICT in Foundation Phase Mathematics as well as their exposure to CPD in ICT.

4.6) Research assumptions

There is a need for Foundation Phase teachers' to be trained on using ICTs in the classroom to improve overall teaching and learning. "The needs for teachers to be literate and have good skills and knowledge in using ICT to improve their teaching methods and approach is desired to promote effective learning as well as to meet the demand of the 21st century teaching skills" (Ghavifekr & Rosdy, 2015, p. 189). This researcher has yet to see research done on whether the CPD programmes offered locally in the Western Cape are in line with

the TPACK model. Another assumption made by the researcher is that many teachers are not fully trained on ICT integration in all mathematics content areas.

4.7) Data collection method and tools

"Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes" (Kabir, 2016). Both quantitative and qualitative data collection methods were used in this study. Usually expressed in words, qualitative data collection methods are mostly non-numerical, descriptive data which includes interviews with open-ended questions and observations (Streefkerk, 2021). Quantitative data collection is expressed in numbers and graphs and can be collected through questionnaire and surveys (McLeod, 2019). In this study the data collection tools used are semi-structured interviews, an online survey and classroom observations.

4.7.1) Qualitative data collection tools

4.7.1.1) Observations

This study made use of two types of qualitative data collection tools, the first is observations in the classroom. When using observation as a method of data collection, the researcher observes the participants in a structured or natural environment (Johnson & Turner, 2003). "Observation is the conscious noticing and detailed examination of participants' behavior in a naturalistic setting" (Cowie, 2009, p.166). Since the interviews and questionnaires mainly focused on the teachers' experiences and the teaching of mathematics through ICT integration, the observations will be used to observe the learning of mathematics through ICT integration. A 'overt' or 'open' non-participant observation was used as the researcher did not participate in the study but merely observed the teachers in their classrooms. A non-participant observation can be used to evaluate the difference between what subjects say and what they do (Stickdorn, Hormess, Lawrence & Schneider, 2018). An overt or open observation occurs when subjects know the researcher is present, but they do not interact, the researcher is there to merely observe. The researcher observed one mathematics lesson of each of the four teachers, ICT needed to be integrated into the lesson. An observation sheet was used to obtain the data from the classroom observations. The observation sheet has specific themes and questions on it that the researcher observed during the lesson. Semi-structured interviews were used as a follow-up after the observations.

4.7.1.2) Interviews

The second qualitative data collection tool is the interviews. "Semi-structured interviews offer a more flexible approach to the interview process" (Ryan, Coughlan & Cronin, 2009:310). In a semi-structured interview, the questions are more open-ended, and the questions prepared by the interviewer merely serve as a framework or guide for the interview (Tod, 2006). This type of interview style allows subjects and interviewer to deepen the points of discussion and go more in-depth (Fauvelle, 2020). In this study, semi-structured interviews were used to interview teachers' who have attended CPD programmes on ICT integration. The interviews focused on the teachers' experiences of the ICT training programmes they attended, whether they found it useful, whether they apply it in their mathematics classroom and whether it has enhanced pedagogy. The interviews were done after the classroom observation and was only done on the four teacher participants that were observed.

4.7.2) Quantitative data collection tools

4.7.2.1) Questionnaire

For the quantitative data collection method, a web-based questionnaire was used. A research questionnaire is one of the most popular forms of quantitative data collection (Harland, 2021).These quantitative questionnaires ask questions that usually warrant a numerical answer for quick data analysis (Harland, 2021). Since survey data can either be cross-sectional or longitudinal, a cross-sectional survey will be used to conduct the research. "A cross-sectional survey collects data to make inferences about a population of interest (universe) at one point in time. Cross-sectional surveys have been described as snapshots of the populations about which they gather data" (Lavrakas, 2008). The platform used to gather the questionnaire data is Google Forms. Google Forms is an online software that is used to administer surveys. The application is grouped in Google Suites. Participants' could access the survey using internet browser. Since the survey is online, the researcher could receive the teacher's responses as soon as they submit the forms. The first question on the questionnaire will ask participant's consent, only if consent is given are participants allowed to proceed with the questionnaire. Data was gathered and stored on the online platform for further analysis and was downloaded onto my hard drive. The participants in the questionnaire are Foundation Phase teachers (excluding the four teachers I have interviewed already), this is to give the researcher a better understanding of teachers' experiences. The

questionnaire was sent to Foundation Phase teachers who teach in the Metro South Education District. All the teachers were selected because they attended an ICT integration course. Thirty-one teachers were sent the questionnaire to complete however, only twenty-five respondents indicated that they were trained in ICT integration and could continue with the study, the other six could not continue. All the teachers were selected because they attended an ICT integration course.

4.8) Sampling

The sample group used in this study was Foundation Phase teachers (one grade one teacher and three grade three teachers). These teachers were selected on their availability and willingness to participate. “In qualitative research,only a sample (that is, a subset) of a population is selected for any given study. The study’s research objectives and the characteristics of the study population (such as size and diversity) determine which and how many people to select” (Mack, 2005:5). For the qualitative research interviews were conducted using purposive (or judgment) sampling. “Researchers may implicitly thus choose a “representative” sample to suit their needs, or specifically approach individuals with certain characteristics” (Ben-Shlomo, Brookes & Hickman, 2013). Purposive sampling groups according to a particular criterion relevant to the study (Mack, 2005), in this study the particular group of participants are Foundation Phase teachers. For this study four Foundation Phase teachers’ were selected from different schools in the Metropole South Education District. The interviews were then conducted with those four teachers after the observation of their mathematics lesson.

In quantitative research, sampling can either be probability or non-probability sampling. For this study non-probability sampling will be used. In non-probability sampling, subjects are selected based on non-random criteria. The aim of non-probability sampling is not to test a hypothesis but rather to understand a small population. This study questionnaire makes use of convenience sampling. “Convenience sampling (also known as availability sampling) is a specific type of non-probability sampling method that relies on data collection from populationmembers who are conveniently available to participate in study” (Saunders, Lewis & Thornhill,2012). Thus, a convenience sample is best suited for this study since the participants are selected by the researcher based on their availability and willingness to

participate in the study.The sample used for the questionnaire was thirty-one Foundation Phase teachers' who are selected based on convenience by the researcher, these participants were sent the link to answer the questionnaire. Although thirty-one teachers were asked, only twenty-five survey responses were retuned and analyzed. The teachers who were interviewed did not fill out the questionnaire as the questions are quite similar. The questionnaires were sent to Foundation Phase teachers who teach in the Metro South Education District. There were thirty-one questionnaire responses however only twenty-five respondents indicated that they were trained in ICT integration and could continue with the study, the other six could not continue. All the teachers were selected because they attended an ICT integration course.

Qualitative sample:

Teacher code	Grade	Years' experience
Teacher A	3	32
Teacher B	3	37
Teacher C	3	3
Teacher D	1	10

Table 1: Teachers grades they currently teach and years' experience

Quantitative sample:

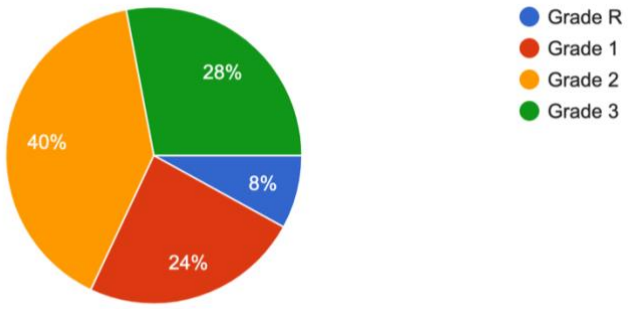

Figure 4: Grades teachers currently teach

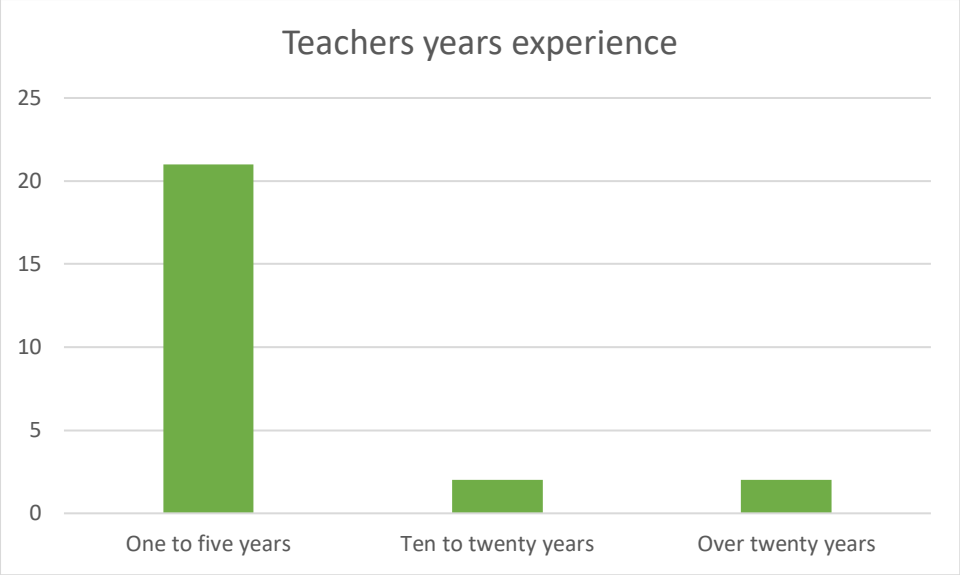

Figure 5: Teachers years' experience

4.9 Data analysis

When it comes to mixed method data analysis, Creswell and Plano Clark (2007) posit "Data analysis in mixed methods research consists of analyzing the quantitative data using quantitative methods and the qualitative data using qualitative methods" (Creswell and Plano Clark, 2007, p. 128). The analysis of data was guided by a theoretical approach based on the TPACK framework. The TPACK model combines three main components of learning namely, technology, pedagogy, and content (Mishra and Koehler, 2006). The TPACK framework "considers the role of technology in teaching" (Swallow & Olofson, 2017, p. 228). This framework builds on Shulman's (1986) "construct of Pedagogical Content Knowledge (PCK) to include technology knowledge" (Koehler & Mishra, 2009:60). This framework is used and attested in various studies to predict natural phenomena. In a study on the role of TPACK on high school Physical Science teachers', Srisawasdi (2012) found that the competency of teachers' TPACK could have a direct impact on learners conceptual learning. (Srisawasdi, 2012). Hofer, Grandgenett, Harris & Swan (2011) designed a rubric to assess the TPACK of teachers in various subjects. This instrument was designed for researchers to use on both in- service and pre-service teachers' "to assess the quality of technology integration, envisioned as a teacher's TPACK-in-action" (Hofer, Grandgenett, Harris & Swan 2011, p.4357). Hofer, Grandgenett, Harris & Swan (2011) does however suggest the use of multiple data sources and making use of data triangulation by combining the multiple data types "would provide a more complete and accurate assessment of a teacher's TPACK" (Hofer, Grandgenett, Harris & Swan 2011,

p.4357). Hence, the use of multiple data collection tools in this research study. This study made use of three instruments for data collection: observations sheets, semi-structured interviews and questionnaires. The data collected through these instruments were grouped, categorized, examined, graphed and put back together in order to address the issues raised in the problem statement and answer the research questions of this study. Manual coding was used to analyze the data collected. Unlike automated data, manual data requires the researcher manually shift through data and create themes and codes (Bodine, 2021).

4.9.1) Qualitative data analysis

Qualitative research takes the form of written text and "uses a systematic and rigorous approach" (Seers, 2012:2) when it comes to data analysis. The aim of qualitative data analysis is to investigate peoples' experiences, their feelings or thoughts about something and why certain things took place (Seers, 2012). Therefore, the qualitative data was analyzed using thematic analysis. Thematic analysis (TA) "is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set. Through focusing on meaning across a data set, TA allows the researcher to see and make sense of collective or shared meanings and experiences (Clarke, Braun & Hayfield, 2015). An inductive approach was used when analysing the data. An inductive approach occurs when the researcher allows the data to determine the themes rather than a deductive approach where the researcher starts the data collection process with preconceived themes (Caulfield, 2022). Therefore, central themes emerged from the classroom observations and the interview transcriptions and were used in this study. The narratives collected from the four classroom observations were in this study. The data from the qualitative data was analyzed and categorized into codes.

4.9.1.1) Coding in qualitative data

The process of coding data plays a vital role in data analysis which involves subdividing data into categories (Basit, 2003). Through qualitative data coding, one can create codes to categorize data extracts (Crosley & Jansen, 2020). "Coding is the process of analyzing qualitative text data by taking them apart to see what they yield before putting the data back together in a meaningful way" (Creswell, 2015, p. 156). "A code can be a word or a phrase that represents a recurring theme or idea in the data" (Bodine, 2021). Qualitative coding increases the validity of the analysis (Delve, n.d.). A variety of coding methods were used

to analyse the data. Since an inductive approach was used as there were no predetermined themes (Caulfield, 2022) and as such an open coding method was used to shift through the raw data and determine an initial set of codes (Delve, n.d.). Initialing the data was categorized into the following codes:

Assigned codes/themes:	Participants responses
Feelings towards training	"it actually helps me a lot" "There's always something I can take out of it, there's always something useful and but the main thing is that unless you, unless you go out and use whatever you've learnt, you lose it" "Good, I would just like more like demonstrations on Maths especially, we get lots of reading workshops but with Maths I would maybe more tools like, like regarding to the reading thing like how to create your own book and the puzzle, game things I would like to know of more tools for Maths because it is a bit of a struggle to find especially like the free apps" "It was helpful and informative. It was definitely stuff that I could bring back into the classroom" "makes you more confident" The programmes did not cover specific mathematical learning areas, it was "general" or "all learning areas" All teachers make use of other sources to upskills themselves on integrating ICT into the classroom e.g. YouTube and researching on the internet.
Curriculum delivery	Three out of the four teachers use ICT in their "daily" practice. The MCO helped with the delivery of CAPS mathematics and the teacher felt "comfortable with technology" "Just opened up some more options really, it yeah things that we hadn't been able to do, we had access to, to another way. We had to work out whether it was going to make better cause that's, our philosophy is we won't use something just because it's new, we will look and see does it make it better, what we doing is it going to add to it" Prepared the teacher for systemic tests Teachers could successfully integrate ICT into the curriculum. "Preparing for Systemic tests so it's quite similar in the way they word the questions"

	"To teach children in a holistic way" "Different methods that you can expand your lesson in"
Resources	All the teachers made use of concrete examples while using the ICT tools. Teacher one: Made use of flash cards for the learners who are still in the concrete stage Teacher two and three: Made use of whiteboards for learners to work out problems presented on the board. Teacher two used to whiteboards to first explain the concept rather than using the smartboard to first introduce the concept. "Children still have to do things, you know to take the bean bag outside, measuring things, to throw the bean bag and measure how far you've measured, that's what small children are about." "The more concrete and where they can play and physical because the other is that children watch a lot of stuff on the screen these days in many ways it's not a novelty for them, to look at videos, you know.
Conceptual understanding	Through the observation, it was clear that learners conceptual understanding improved after the use of the ICT tool.
Benefits	Teachers mentioned the fact that they reuse the slides and data for the next year or for revision which ultimately saves time and resources making teaching and learning more effective and meaningful. "I download a lot of things for whatever skill that I want" "and the nice thing about the, the technology is the that the when you find nice resources they saved and you've got them to use again, you know so once you, if you, if you develop a whole sort of bank of data items or shape items or like you those sums on the board, you've got it, you use it again, you're not losing it, you're not having to reinvent the wheels. So, then instead of doing instead of, of generating the same type of thing every year you can look at what you used before and you can say "well how can I improve this?", you know "how can I modify this?", "how can I move on with this?" It, it helps you to, to develop what you got as opposed to just reusing stuff"

	"The nice thing with having the Smartboard and having the Google Drive and everything is that once you've got something you can keep it. So, so like now for instance we developed a shared per room where we got lots of it might be little game sites that we found, free game sites cause our school doesn't pay for any membership for anything" "Sometimes I even create my own (videos) just to demonstrate maybe something if I'm not in the class"
Pedagogical effects	"Obviously to better it for all the different levels in the class and also for my teaching like to, to mentor my colleagues like that I must oversee in the phase like to help them if they struggle with different terms" "I use it every day so in group work I use it, yeah. I love using the screen just cause its visual aid for them as well and they get very excited" "I think children like technology, don't they? They, they it, it engages them, you know it's big, it's, it can be exciting" "I think it motivated them; it gives them like excitement during the lesson. They really enjoy when I put on" "Could give meaningful and interactive lessons"

Table 2: Initial assigned codes and participants responses

From the table above (table 2) we see that the open coding allowed for the initial codes of feelings towards training, curriculum delivery, resources, conceptual understanding, benefits, and pedagogical effects. In order to get to a focused coding where a finalized set of codes and themes were used (Delve, n.d.), various coding methods were used. Value coding was used to code teachers epistemic stance and epistemological beliefs towards ICT's and the CPD programmes they attended (Delve, n.d). Since the codes in this study were designed using different parts of data sets, thematic analysis coding was used (Delve, n.d.). Finally axial coding was used as the initial table (table 2) had themes that could be linked together instead of being a theme on its own (Simmons, 2017). Through the focused coding the new themes were re-coded into the themes below (Table 3).

Focused codes/ Themes:	Participant responses
Assessment	The use of CPD programmes on ICT integration helped prepare the teacher for systemic tests. Teachers could successfully integrate ICT into the curriculum. “Preparing for Systemic tests so it’s quite similar in the way they word the questions”
Barriers	**Financial:** The schools opt not to pay for any site subscriptions, so teachers have to find free sites or apps which is a barrier to the usage of ICT. we developed a shared per room where we got lots of it might be little game sites that we found, free game sites cause our school doesn’t pay for any membership for anything” I would like to know of more tools for Maths because it is a bit of a struggle to find especially like the free apps” The data is showing that teachers need to be shown what these free sites and apps are in their training. This is limiting
Teachers epistemological beliefs	“it actually helps me a lot” “There’s always something I can take out of it, there’s always something useful and but the main thing is that unless you go out and use whatever you’ve learnt, you lose it” “Good, I would just like more like demonstrations on Maths especially, we get lots of reading workshops but with Maths I would like more tools to use, for example the reading there is how to create your own book and the puzzle, game things I would like to know of more tools for Maths because it is a bit of a struggle to find especially like the free apps” “It was helpful and informative. It was definitely stuff that I could bring back into the classroom” “makes you more confident” We had to work out whether it was going to make better cause that’s, our philosophy is we won’t use something just because it’s new, we will look and see does it make it better, what we doing is it going to add to it” All teachers make use of other sources to upskills themselves on integrating ICT into the classroom e.g. YouTube and researching on the internet.

Curriculum delivery	Three out of the four teachers use ICT in their "daily" practice. The MCO helped with the delivery of CAPS mathematics and the teacher felt "comfortable with technology" "Just opened up some more options really, things that we hadn't been able to do, we had access to, to another way" "To teach children in a holistic way" "Different methods that you can expand your lesson in" The programmes did not cover specific mathematical learning areas, it was "general" or "all learning areas". Data shows that all teachers have not received training for specific learning areas.
Resources	All the teachers made use of concrete examples while using the ICT tools. Teacher one: Made use of flash cards for the learners who are still in the concrete stage Teacher two and three: Made use of whiteboards for learners to work out problems presented on the board. Teacher two used to whiteboards to first explain the concept rather than using the smartboard to first introduce the concept. "Children still have to do things, you know to take the bean bag outside, measuring things, to throw the bean bag and measure how far you've measured, that's what small children are about." "The more concrete and where they can play and physical because the other is that children watch a lot of stuff on the screen these days in many ways it's not a novelty for them, to look at videos, you know.
Conceptual and mathematical understanding	Through the observation, it was clear that learners conceptual understanding improved after the use of the ICT tool.
Benefits	Teachers mentioned the fact that they reuse the slides and data for the next year or for revision which ultimately saves time and resources making teaching and learning more effective and meaningful. "I download a lot of things for whatever skill that I want" "and the nice thing about the, the technology is

	the that the when you find nice resources they saved and you've got them to use again, you know so once you, if you, if you develop a whole uh sort of bank of data items or shape items or like you those sums on the board, you've got it, you use it again, you're not losing it, you're not having to reinvent the wheels. So, then instead of doing instead of, of uh generating the same type of thing every year you can look at what you used before and you can say "well how can I improve this?", you know "how can I modify this?", "how can I move on with this?" It, it helps you to, to uh develop what you got as opposed to just reusing stuff" "The nice thing with having the Smartboard and having the Google Drive and everything is that once you've got something you can keep it like now for instance we developed a shared per room where we got lots of it might be little game sites that we found. "Sometimes I even create my own (videos) just to demonstrate maybe something if I'm not in the class"
Implications for teaching and learning	**Teaching:** "Obviously to better it for all the different levels in the class and also for my teaching like to, to mentor my colleagues like that I must oversee in the phase like to help them if they struggle with different terms" "I use it every day so in group work I use it, yeah. I love using the screen just cause its visual aid for them as well and they get very excited" **Learning:** "I think children like technology, don't they? They, they it, it engages them, you know it's big, it's, uh it can be exciting" "I think it motivated them; it gives them like excitement during the lesson. They really enjoy when I put on" "Could give meaningful and interactive lessons"

Table 3: Focused codes/themes and participants responses

4.9.2) Quantitative data analysis

Through a quantitative approach data is analyzed as statistics and graphs and to be calculated into averages and other numerical data points (Elliott, 2020). As mentioned previously the quantitative data (questionnaire) will collected on Google Forms, the application automatically summaries all data collected into graphs and charts for easy analysis. The data was then be exported automatically into a Microsoft Excel spreadsheet, which is an added function on the Google Forms application. When data was converted into the Excel spreadsheet, the data was analyzed and grouped into categorize based on the themes that emerged from the data. The data was then put into graphs using the Microsoft Excel functions and statistics were drawn from this data.

4.10) Validity and reliability

To understand the meaning of validity and reliability in research, we must look at what this means in both qualitative and quantitative research and how it relates to this study.

Validity

"Validity is defined as the extent to which a concept is accurately measured in a quantitative study" (Heale & Twycross, 2015, p.66). There are four types of validity namely, construct validity, content validity, face validity and criterion validity. In the case of this research study construct, content and face validity are relevant. Construct validity is central to establishing overall validity, it assesses whether a tool really represents the thing we are interested in measuring (Middleton, 2019). Construct validity is achieved through ensuring whether the measurements and indicators were carefully developed based on existing knowledge (Middleton, 2019). This form of validity is present in this research study as the research aimed to find what teachers' experiences are with ICT integration, the teachers' were asked about the relevant factors.

"Content validity assesses whether a test is representative of all aspects of the construct. To produce valid results, the content of a test, survey or measurement method must cover all relevant parts of the subject it aims to measure" (Middleton, 2019). This research study aimed to investigate all effects the relevant CPD has on ICT integration in the Foundation Phase classroom of the participants. "Face validity considers how suitable the content of a

test seemsto be on the surface (Middleton, 2020). This research aimed to have a high face validity because the questionnaire aimed to have a good representation of what was set out to test.

When it comes to testing the validity and reliability of both qualitative and quantitative research, the same criteria cannot be applied in terms or merit and worthiness (Cypress, 2017).Therefore, looking at the validity of qualitative research, researchers have argued that validity is not applicable in this research approach (Golafshani, 2003). Researchers developed their own terms for validity in qualitative research namely, quality, rigor, and trustworthiness (Golafshani, 2003). "Researchers assert that rigor of qualitative research equates to the concepts reliability and validity, and all are necessary components of quality" (Cypress, 2017:254). "To validate means to investigate, to question, and to theorize, which are all activities to ensure rigor in a qualitative inquiry" (Cypress, 2017:257). Every effort was made to see that the instruments used in the data collection process have been validated.

Reliability

"The second measure of quality in a study is reliability, or the accuracy of an instrument. In other words, the extent to which a research instrument consistently has the same results if it isused in the same situation on repeated occasions" (Heale & Twycross, 2015, p.66). The instrument used to collect data is a questionnaire and through this questionnaire the researcher attempted to collect data to answer the research questions put forward in this study. When analysing the data collected, the researcher aimed to be as accurate as possible and to get more reliable results. In qualitative research, the most important test of a qualitative study is its quality (Bashir, Afzal & Azeem, 2008). Stenbacka (2001) stated that reliability in a qualitative study is to generate understanding and therefore the interview data collected will be used to further understand the effects CPD programmes had on ICT integration.

By using multiple instruments to collect data through the process of data triangulation, the findings are more valid and reliable. Data triangulation is a strategy to improve the validity and reliability of research (Golafshani, 2003), making "use of two or more data sources, methods, investigators, theoretical perspectives and approaches to analysis in the study of a single phenomenon and then validating the congruence among them" (Brink, 1993:37).

4.11) Ethical Considerations

"Research ethics refers to a wide variety of values, norms, and institutional arrangements that help constitute and regulate scientific activities….Guidelines for research ethics specify the basic norms and values of the research community" (National Research Ethics Committees, 2019). Every effort was made by the researcher to ensure this study employs the ethical standards outlined by the Senate Research committee at the University of the Western Cape. Since the researcher had to go into schools for data collection, all COVID-19 protocols were adhered to during the research. As per the new, amended COVID-19 protocols in South Africa, including Regulation 16A (wearing of face masks) has been repealed, mask wearing is not mandatory. As per the Regulation 67(4)(b) in the Government Gazette, social distancing is exempt in schools. Even though the COVID-19 protocols have been amended, the researcher still maintained a healthy distance from participants for my safety and the safety of others. This researcher acknowledges the POPI Act which came into effect in July 2020 (Adams, Veldsman, Ramsay & Soodyall, 2021). "The POPI Act, is a pieceof legislation designed to protect any personal information which is processed by both privateand public bodies (including government). Some exceptions exist, but every person who collects, stores, and otherwise modifies or uses information (i.e., processes information) is responsible under the POPI Act to comply with the conditions required for the lawful processing of personal information" (Kandeh, Botha & Futcher, 2018). The researcher also made every effort to adhere to the POPI Act when conducting the research and working with participants' personal information.

Ethical clearance permission was applied for and approved by the University of the Western Cape's research ethics committee. Since the research will be conducted at schools, research permission was applied for and approved by the Western Cape Education Department in order to conduct the observations and interviews at schools with teachers. Permission was asked and given from the school principals to conduct the observations and interviews at their schools. When it comes to the research subjects; the teachers'; they were asked permission and to filled out a consent form for both the questionnaire and to participate in the observations and interviews. The parents of the learners were sent an information letter and a consent form to indicate that they give permission for their minor children to partake in the study. The learners were asked to sign an assent form to indicate their consent to partaking in the study. It was made clear in the information letter given to all participants'

that they can withdraw at any time and there will be no negative consequences if they do choose to withdraw. Permission was given by all parties involved in the study.

All COVID-19 protocols were adhered to when conducting the observations and interview. Anonymity and confidentiality were upheld. “Issues of confidentiality relate closely to issues of anonymity” (Wiles, Charles, Crow & Heath, 2006). The anonymity of the participants’ will be upheld as both the names of the teachers’ and of the schools were not revealed in the study and codes were used instead of teachers names (refer to table one for codes). In accordance with the POPI Act, all personal information of participants’ were not revealed and are confidential. “Confidentiality in research are concerned with who will have access to the data and how the data will be used” (Wiles, Charles, Crow & Heath, 2006). The data is confidential and only used for the purpose of this research study. The online data is stored in a password protected hard drive and any physical data collected such as interview and observation transcript print outs were filed and kept in a locked storage unit and stored for a minimum of five years and will be disposed of thereafter.

4.12 Summary

This chapter gave an in-depth description of the research designs and methodologies used to answer the research questions set out in this study. The chapter describes the research setting, participant sample, research paradigm and assumptions as well as the data collection methods and tools used in this study. The chapter further discusses how the data will be analyzed in the study as well as the issues pertaining to validity and reliability and how it will be maintained. The ethical considerations were discussed in detail. The next chapter will analyze and illustrate the data that was collected.

Chapter Five

Data analysis

5.1) Introduction

In this chapter the data analysis is discussed. The data collected for both the quantitative and qualitative research was analyzed under various themes that came from the data. This research study makes use of an inductive approach to determine the themes of the study which means the researcher allowed the data to determine the themes (Caulfield, 2022). The themes that emerged from the data collection include:

Barriers to ICT integration

This is how often teachers received ICT training as well as how often they integrate ICT into the Foundation Phase mathematics classroom. This theme also looks at the various barriers to ICT integration and the reasons for this. This theme emerged from the data as teacher listed their reasons for not integrating ICT's into their daily classroom practice.

Teacher perception towards ICT

This theme looks at the perceptions of teachers and their epistemological beliefs. The topic of this study is about CPD programmes that teachers attended and whether these programmes assisted teachers in successfully integrating ICT into mathematics teaching and learning. Therefore, looking at the teachers perceptions towards ICT is necessary as it informs this study on the value of CPD. The sub-themes that emerged from this theme are:

Teachers epistemic stance towards integrating ICT into their practice

This is the teachers' confidence and outlooks towards making use of ICT's in the mathematics classroom and their reasons for the perception.

Teachers epistemological beliefs and efficacy towards the CPD programmes they attended

This sub-theme looks at teachers' feelings towards the training programmes they attended. Here teachers share their view on the CPD programmes and give their perception on the value of these programmes.

The implications for teaching and learning

To answer the research questions, the data collected looks at how the CPD programmes attended by teachers impacts on teaching and learning. To do this look at the following sub-themes:

Curriculum delivery

This sub-theme looks at the impact the training had on teachers ability to deliver the CAPS curriculum.

The effects of ICT integration on Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge (PK)

This sub-theme looks at the effects of integrating technology into teaching and learning and the impact it has on PCK and PK.

Conceptual practice and mathematical understanding

Through the classroom observations, the researcher was able to get a glimpse into how teachers make use of ICT's to better learner understanding.

Resources in teaching and learning

This theme looks at the resources used by the participants for mathematics teaching and learning. The theme not only looks at the ICT tools and resources but the concrete as well. The following sub-themes emerged from the data collection process:

ICT tools and applications

This is the various ICT tools, applications and programmes used by the sample teachers in their mathematics lessons. The teachers were asked about a number of devices and applications used. The teachers also mentioned online applications, programmes and ICT tools that were not mentioned by the researcher.

Combining the concrete and abstract resources in teaching and learning

Many of the teachers made use of concrete resources when teaching mathematics. For most of these teachers the concrete was used as an addition to the technological resource however one teacher shared her view on using concrete resources in the Foundation Phase and using ICT's when necessary or merely as enrichment; a view shared by many teachers worldwide. Thus, the sub-theme emerged.

The benefits and effectiveness of ICT

This theme emerged from the data as all teachers shared similar sentiments about the effectiveness and benefit of ICT's on their time. Teachers share their views on how ICT's has helped them save work to reuse for the next year or for revision which results in better overall practice.

Assessment

The theme of assessments emerged from one of the interviewed teachers who shared how ICT's has assisted with assessment. The teacher mentioned the systemic tests and how there are online applications which helped her prepare learners for the systemic tests.

These themes will be analyzed below and further discussed in the next chapter.

5.2) Barriers to ICT integration

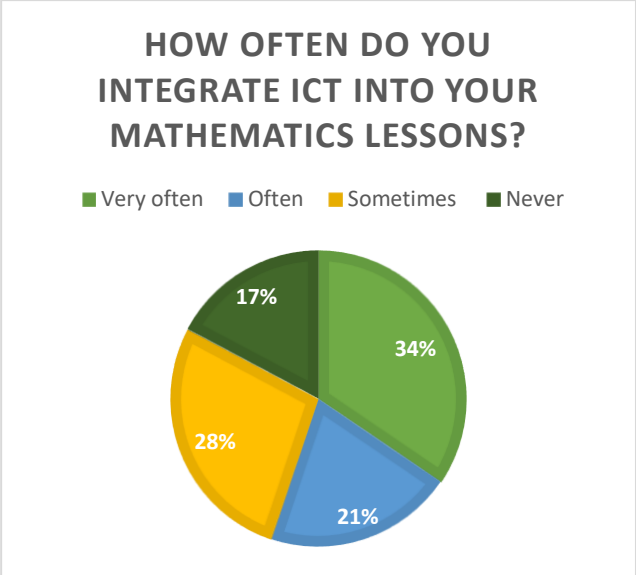

Figure 6: How often teachers integrate ICT into their mathematics lessons

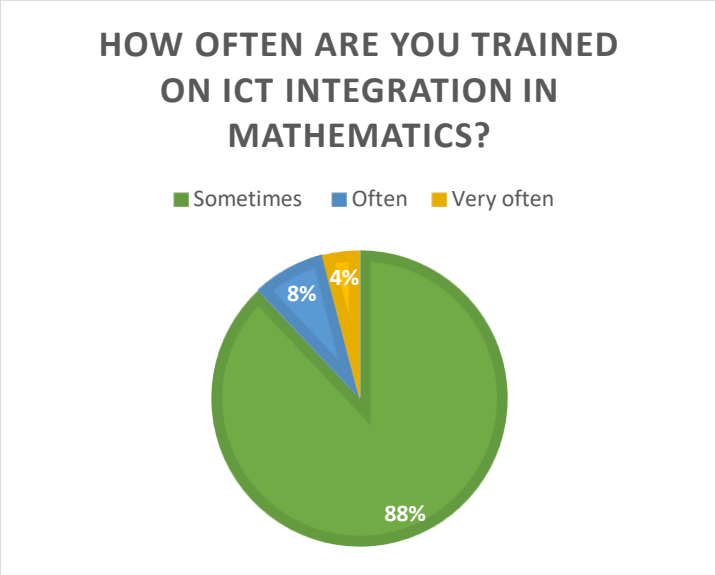

Figure 7:How often teachers are trained on ICT integration

One of the central themes what emerged from both the qualitative and quantitative data was the hesitance of some teachers to use ICT's in the classroom. The figure above (figure 6) illustrates the number of teachers who make use of ICT in their lessons very often, often, sometimes, and never. 17% of teachers indicated that they did not make use of ICT's in their mathematics lessons. 83% of the teachers indicated that they make use of ICT's in the mathematics classroom, however, majority of those teachers stated that they do not use the

methods taught in their professional development programmes in their lessons but rather other methods they were taught. Figure 7 shows us how often teachers are trained on ICT integration in mathematics. The majority of teachers (88%) indicated that they are trained sometimes. Considering that the other categories were very often and often, the sometimes tells us that they were not trained often.

When asked whether the teachers use the applications and programmes taught in their practice, all interviewed teachers stated that they make use of these applications and programmes however, Teacher B stated that it is not always appropriate, so she does not make use of these applications and programmes daily like the others.

One of the other barriers that came up in the teacher interviews was the financial barrier. Lack of resources was a reason teachers indicated to not using ICT's in their classrooms, but a common trend came up amongst teachers who make use of ICT's, the lack of access to free "sites" or free online resources. Teacher C stated she would like to know of more online mathematics tools to use but it is "a bit of struggle" to find free apps. The teachers shared that their schools do not pay for membership or subscriptions to any sites and therefore they have resorted to looking for free websites to use.

5.3) Teachers perceptions towards ICT

5.3.1) Teachers epistemic stance towards integrating ICT into their practice

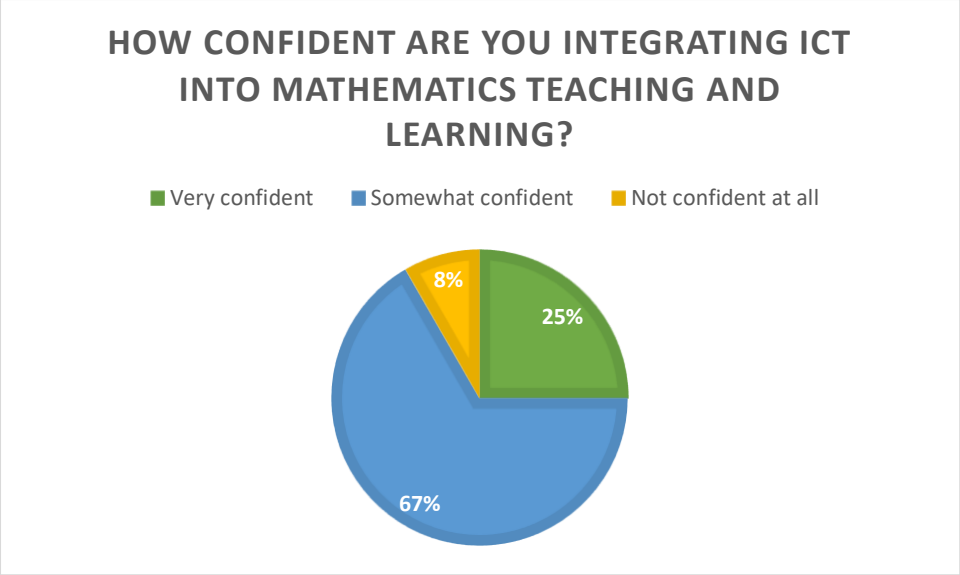

Figure 8: How confident teachers integrating ICT in mathematics teaching and learning

Lack of confidence was listed as one of the contributing factors towards teachers not integrating ICT into mathematics teaching and learning. The figure above (Figure 8) shows teachers confidence towards integrating technology into their mathematics teaching and learning. Majority of the teachers indicated that they are either very confident or somewhat confident with only 8% indicating that they are not confident. Teachers A and C both shared the same sentiments about the CPD programmes making them more confident in using ICT in mathematics lessons. In the questionnaire teachers were asked to rate their level of confidence towards various ICT tools. The results are illustrated below:

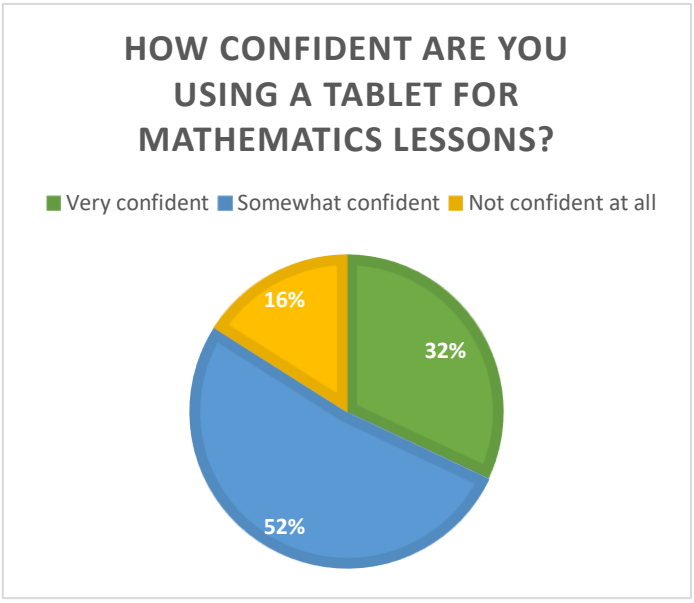

Figure 9: How confident teachers are using the tablet for mathematics lessons

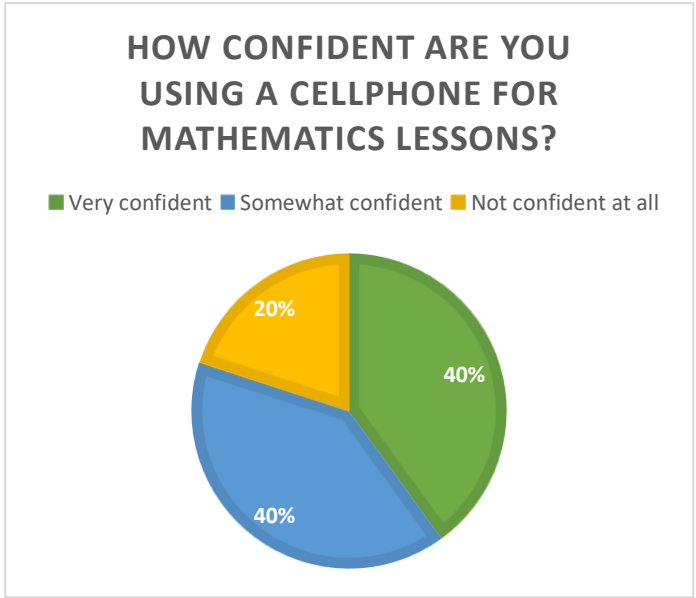

Figure 10: How confident teachers are using cellphones in the mathematics lessons

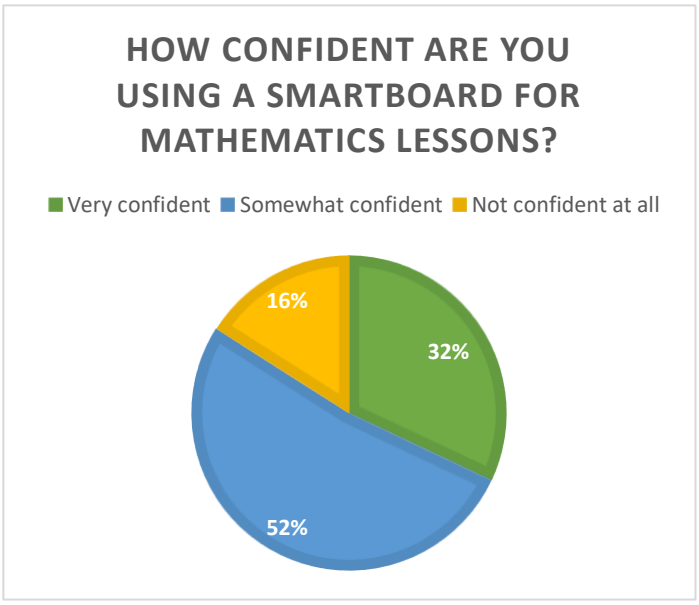

Figure 11: How confident teachers are using the Smartboard for mathematics lessons

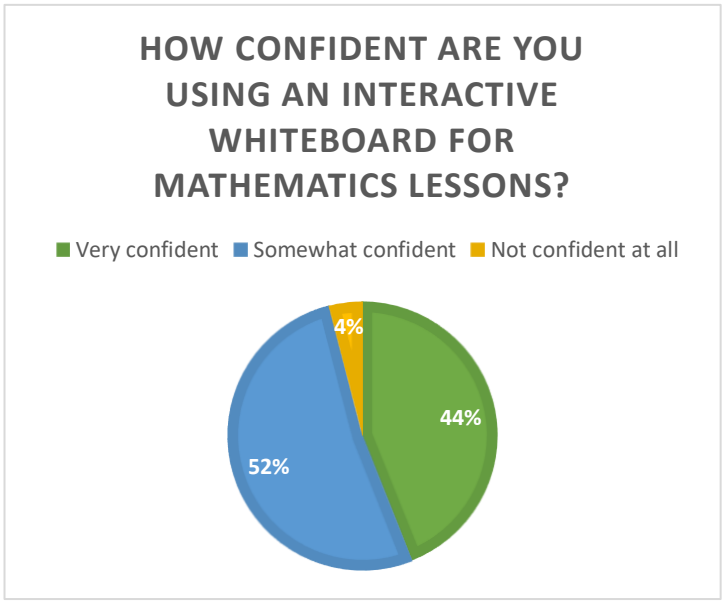

Figure 12: How confident teachers are using IWB for mathematics lessons

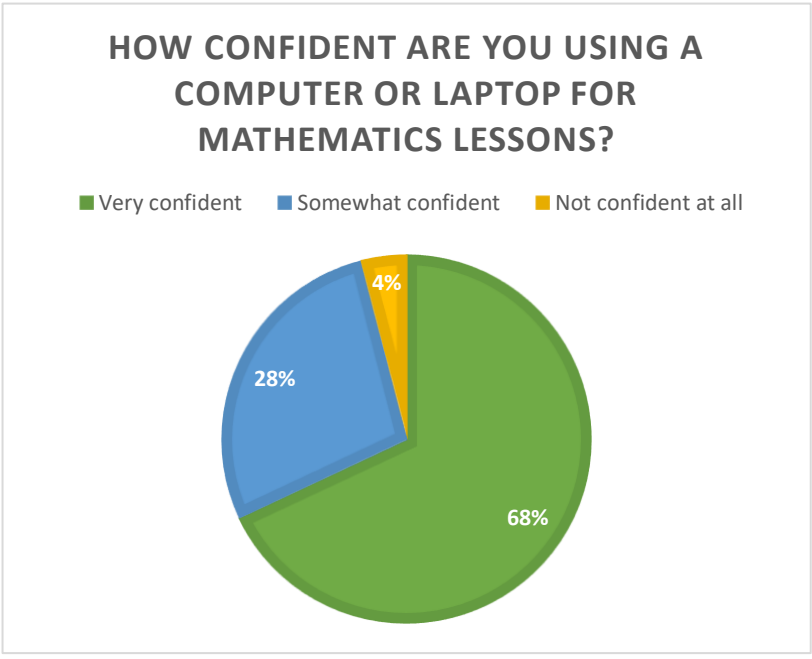

Figure 13: Teachers confidence towards using computers or laptops for mathematics lessons

From the figures above (figure 9 - 13) we see that the teachers are not “very confident” in using the various ICT tools. For most tools, majority of the teachers indicated that they are between very confident and somewhat confident.

5.3.2) Teachers epistemological beliefs and efficacy towards the CPD programmes they attended

The teachers felt that the ICT training was "helpful" and "informative". Teacher B offered a difference perspective, she expressed that their "philosophy" is that they as a school or grade will look at what they were taught in the CPD programmes and decide whether they will use it or not, "we won't use something just because it's new, we will look and see does it make it better" and if it is going to add to what they are already doing.

The figure below (figure 14) shows the percentage of teachers who attended an ICT integration course at the Cape Teaching and Leadership Institute (CTLI). Of those teachers who attended the CTLI course/s only two teachers (illustrated in figure 15) indicated that they did not find the training course/s useful in helping them integrate ICT into their teaching.

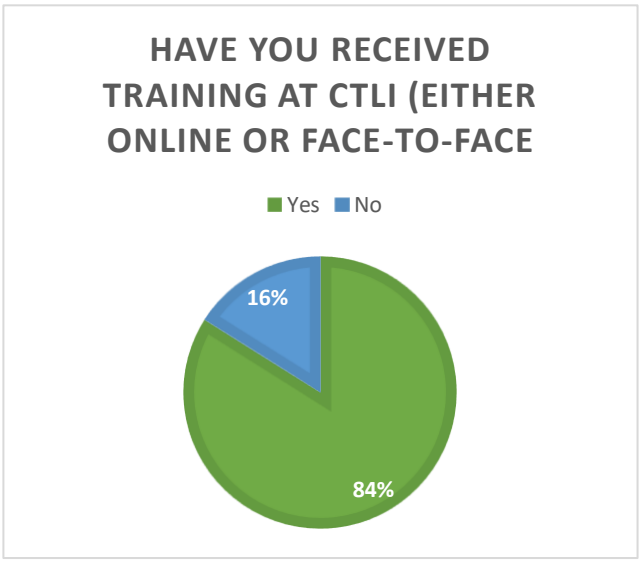

Figure 14: Teachers who have attended an ICT integration course through CTLI

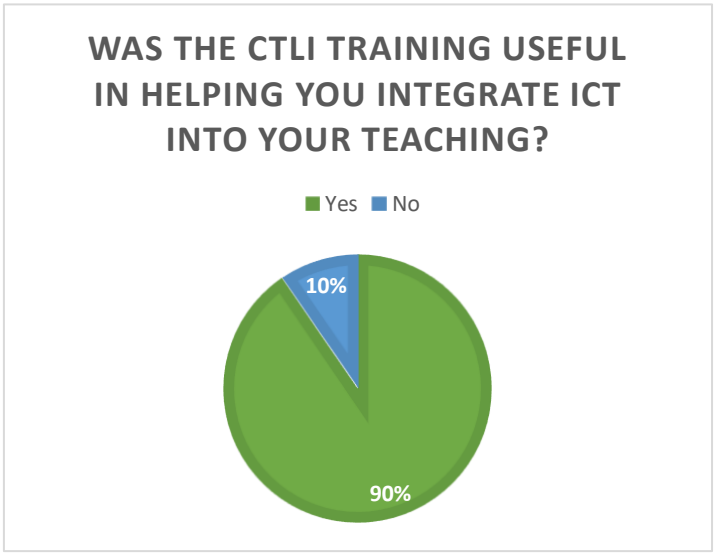

Figure 15: Teachers indicated whether the ICT integration courses offered at CTLI were useful

5.4) Implications for teaching and learning

5.4.1) Curriculum delivery

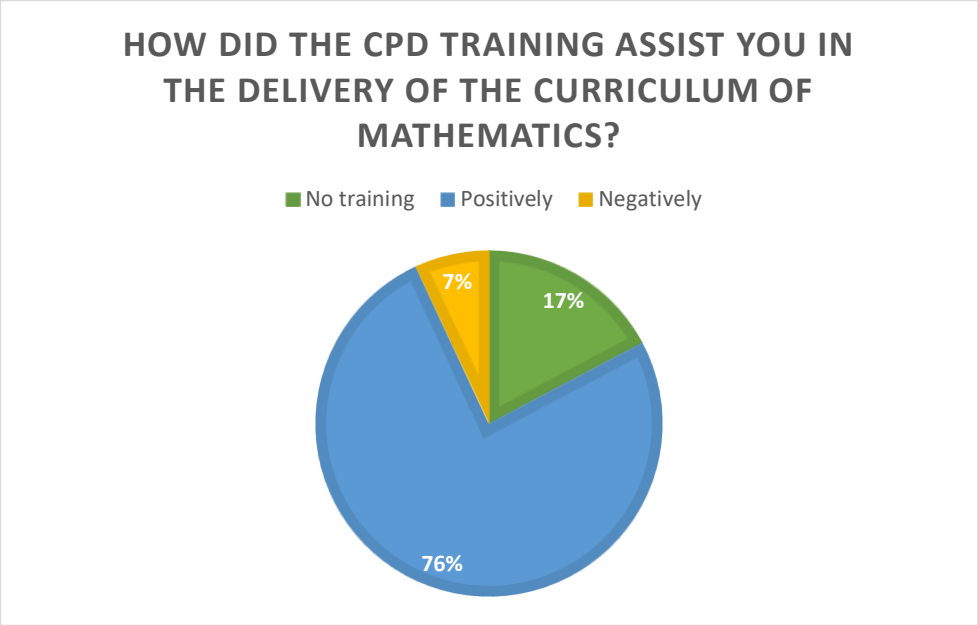

Figure 16: Teachers views on the CPD programmes assisting them with curriculum delivery

The figure above (figure 16) shows teachers views on whether the CPD training they received assisted them in the delivery of the mathematics curriculum. 76% of the teachers who participated in the study indicated that the training they received positively impacted on their ability to deliver the curriculum content in mathematics.

Teacher code	Thoughts on how the CPD programme assisted with curriculum delivery
Teacher A	"Enhanced my understanding of mathematics" It provided more resources to use in the mathematics classroom It made me more confident in teaching mathematics using ICT.

Teacher B	"Opened me up to new options" "Added to" the curriculum
Teacher C	"I am comfortable with using technology to deliver the curriculum" "Delivery of CAPS was easier especially through the MCO" "It helps me prep for systemic"
Teacher D	"The training helped me teach in a more holistic way. I teach in a different, new way. No longer makes use of the writing board (chalk or marker boards) even for handwriting – it is all done on the Smartboard"

Table 4: How CPD programmes assisted in mathematics curriculum delivery

Table 4 above and table 5 below shows the teachers experiences of how the CPD programmes they attended assisted in mathematics curriculum delivery. All the interviewed teachers (table 4) mentioned the benefits that their training had on their curriculum. That it "enhanced" their understanding of mathematics and made delivery of the CAPS curriculum easier with special mention to the MCO (Maths Curriculum Online) programme. Teacher B stated that it added to the curriculum and open up more options for the teachers. Teacher D mentioned that it helped her teacher in a more "holistic way" and that she has moved away from the traditional chalkboard to a fully digital and 'smart' teaching and learning approach. Teachers felt that these programmes exposed them to different ways of teaching mathematics and broadened their "knowledge of number sense". It helped learners understand complex concepts better through the use of visuals.

Teachers views from survey data:	Views on how CPD assisted in curriculum delivery
Improves teaching methods	"Training provides guidance on ways to improve lessons and implement new ways of getting concepts across" "Broaden my knowledge of number sense" "It exposed me to other ways of teaching mathematics"
Influence on learners and learner outcomes	"It assists in developing diverse lesson plans and interactive lessons in class" "Making lessons entertaining for the learners and myself" "It showed me how to make it more interesting for the learners" "It helped a lot in a positive way and the children enjoy it as well" It simplified complex concepts to a visual that wants learners to know more, building interest in subject area. "By making the lesson more interesting and capturing attention. Using more visual and audible techniques in the lesson. Learners can relate to their environment by the integration of mathematical skills"

Table 5:Results from survey data on how CPD assisted teachers with curriculum delivery

Teacher confidence was also mentioned as teachers spoke about their confidence and comfortability when delivering the mathematics curriculum due to their training. A common trend that was discovered in the survey data was that teachers found their training allow them to deliver the mathematics curriculum and in more "interesting" and "entertaining" way and that it assisted them in creating more "diverse lessons plans".

5.4.2) The effects of ICT integration on Pedagogical content knowledge (PCK) and Pedagogical Knowledge (PK)

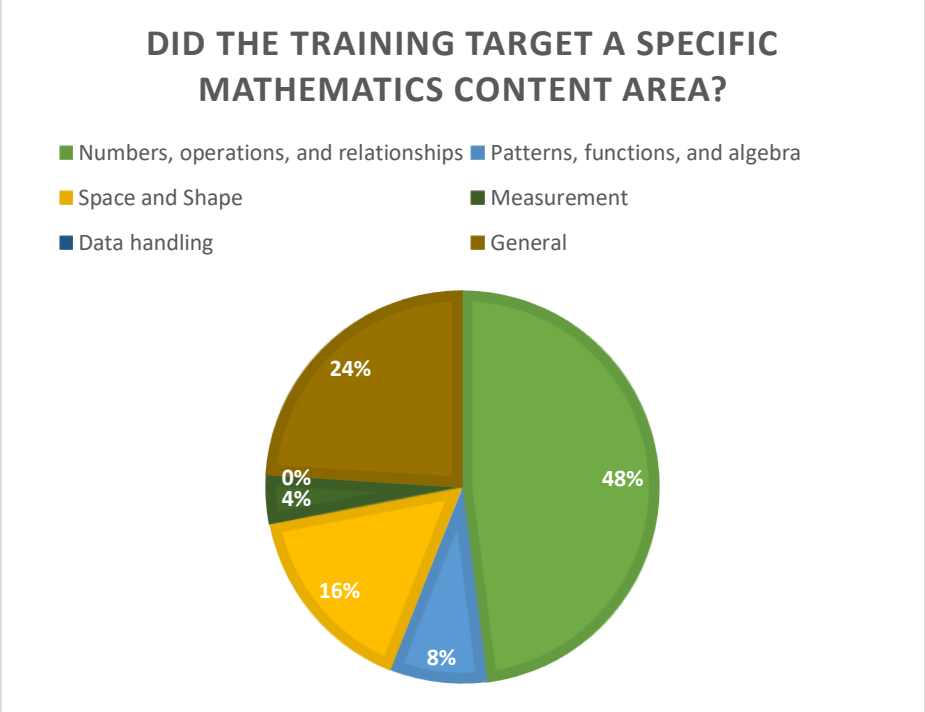

Figure 17: Mathematics content areas that were covered in the CPD programmes

In figure 17 we can see that teachers were trained on a variety of content areas. 48% of the participant teachers covered Numbers, Operations and Relationships while 24% stated that their training covered mathematics in general. 16% covered Space and Shape and 8% covered Patterns, Functions and Algebra. There were no teachers who attended a CPD programme on how to integrate ICT into Data Handling.

Teacher code	How did the training assist teaching?	How did the training assist learning?
Teacher A	It helped to teach better at different levels. It helped me to mentor colleagues	Helped to bring the concept across better
Teacher B	In mathematics lessons, I would use data slides and rotating shapes. When you find nice resources, you can use it over and over again instead of writing it again	Children like technology so they respond well to it but I prefer concrete examples. To 21st century learners technology is a novelty, so they really enjoy the more concrete objects and examples.

Teacher C	I use it daily. I also use it for group work. I use a lot of visuals. It causes excitement in the classroom.	It motivates them (the learners) It causes excitement, they look forward to it. They enjoy the videos and learn from it.
Teacher D	Send home videos to help parents during COVID-19 teaching periods where learners only came to school every second day. Teaching changed over the years so the Parrot's training helped me on things I did not know.	I could create meaningful lessons to assist learners in learning. Learners can interact with the board which helps them learn.

Table 6: How skills acquired assisted teaching and learning

5.4.3) Conceptual and mathematical understanding

As illustrated in the tables below (Tables 7 – 10), the teachers successful integration of ICT into teaching and learning and learners conceptual and mathematical understanding improved learners mathematical achievement through the use of the ICT tools and applications. However, in the case of Teacher B, learners conceptual understanding improved due to the use of concrete resources like her whiteboard and their pages they worked with on the mat. The teachers philosophy (as mentioned earlier) was based on using what is needed for the lesson and she felt the use of concrete examples and resources were better suited to teach that specific concept. Teacher A and Teacher D also made use of concrete resources, Teacher A used flash cards and Teacher D the mini whiteboards, to scaffold. Overall learners understanding of the concepts taught did improve but it was not entirely through the use of ICT.

Questions	**What was observed**
What ICT tool/s was used in the mathematics lesson?	Smartboard Laptop YouTube Twinkl.com
What problems did learners have when it came to the understanding of mathematical concepts before ICT was introduced? **Humanistic practice**, influencing the creative active knowledge of learners	Learners struggled with the following concepts: • Counting days of the week • Hundreds, tens and units • More than / less than
How has the ICT tool/s impacted learner's level of	Through the use of the smartboard and

understanding during lesson?	laptop, the learners could practice how to count the days of the week in different ways using different types of activities on the smartboard. For the hundreds, tens and units learners did a whole class activity using the smartboard and as a class they got seven out of eight. During the lesson, the activities that the teacher put on the board allowed learners to practice more than and less than.
How has learner's level of understanding changed after lessons? (PCK and PK vs learner understanding)	After the lesson, the learners did place value (hundreds, tens and units) with flashcards. The use of the smartboard was a good introduction to the topic of place value. Those ability groups who struggled with the concept of place value were asked to remain on the mat and the teacher let them do a more concrete activity using flash cards and their mini white boards. The other groups went to their tables and did a worksheet. The teacher put this worksheet up on the smartboard and explained to learners what to do and how to do it. The smartboard came to good use because the teacher could make the worksheet big for everyone to see and use it to explain the work, this betters their understanding.
Does teacher make use of ICT skills taught to better conceptual understanding? How? Conceptual Practice	Yes. The teacher shows the use of her ICT skills because she used more than one app on the smartboard and made use of the features of the smartboard to help learners practice and understand the mathematical concepts.
How did the teacher make use of the tool/s to better mathematical understanding? Local practice and PCK and PK	The teacher made use of the smartboard to better the understanding of certain concepts by having learners interact with the smartboard activities and then used her white writing board to further explain the questions on the smartboard. So, a mix of media was used to better learners understanding.
To what extent is ICT used as a means of scaffolding? Conceptual practice	When learners struggled with a concept, the teacher would find more examples on her laptop to put on the smartboard. The app tells you if your answer is incorrect so if a learner who came up got

	the answer incorrectly, the teacher would give the child another similar question to answer but before they answer the teacher will ask the child and/or the class where that child went wrong and the child will then need to apply this new knowledge to the new question. When learners struggled with more than and less than, the teacher put the activities on the smartboard to help them, but she also made use of concrete objects (counters) and learners used the counters to answer the questions. The teacher also used her white writing board to further explain the concepts. The teacher played a YouTube video for learners to better understand in a fun and colourful way.

Table 7: Observations for Teacher A

Questions	**What was observed**
What ICT tool/s was used in the mathematics lesson?	Smartboard Google Slides
What problems did learners have when it came to the understanding of mathematical concepts before ICT was introduced? **Humanistic practice**, influencing the creative active knowledge of learners	Learners are introduced to division with triple digits and struggled to understand the concept at first.
How has the ICT tool/s changed learner's level of understanding during lesson?	The teacher did not make use of the smartboard to teach the lesson at first. She used her big white board and learners used their mini white boards on the mat but later on she used the smartboard to project the sums for learners. This allowed learners to see the sums on the screen and verbally interact with the board when giving the answer.
How has learner's level of understanding changed after lesson? (PCK and PK vs learner understanding)	After the lesson, it was clear that learners understood the concept of dividing three-digit numbers. However, this was largely due to the teacher teaching on the mat with the whiteboard and not due to the use of ICT. The teacher is not very keen on using ICT's during her mathematics lessons. She believes in using more concrete examples and as such mostly uses ICT's at the end to project sums as consolidation or to send homework to parents.
Does teacher make use of ICT skills taught to better	Not really. The teacher mostly taught without

conceptual understanding? How?	ICT's and only used it when putting up the sums after the whole class teaching.
How did the teacher make use of the tool/s to better mathematical understanding? Local practice and PCK and PK	The teacher made use of the smartboard and Google Slide to consolidate what was taught by giving learners an activity to do on dividing.
To what extent is ICT used as a means of scaffolding?	Not much. Teacher merely used the ICT tool to display the sums. The sums catered for all levels.

Table 8: Observations for Teacher B

Questions	What was observed
What ICT tool/s was used in the mathematics lesson?	Flat screen TV Laptop Microsoft PowerPoint
What problems did learners have when it came to the understanding of mathematical concepts before ICT wa introduced? **Humanistic practice**, influencing the creative active knowledge of learners	The topic they were doing was money. Learners struggled to understand the following: • The concept of rand and where the R goes (they say 100 instead of 100 rand and write 100 instead of R100). • The concept of cents especially the one cent. • The concept of rounding off and then adding money.
How has the ICT tool/s changed learner's level of understanding during lesson? PCK and PK vs learner understanding)	The teacher used the tool (the TV) to show learners that there needs to be a R in front of the number. The teacher used the slideshow to teach learners that the one cent does not exist anymore and what learners can use instead. The teacher also used images of real-world shopping items such as washing powder and meat to show learners how many is calculated and written.
How has learner's level of understanding changed after lesson?	After the lesson, it was clear learners understood these concepts because learners could successfully do an activity where they had to round up the cent and add various shopping items together and they now knew to add the rand sign.
Does teacher make use of ICT skills taught to better conceptual understanding? How?	Yes. Teacher displayed the pictures and the prices with them to help learners understand that the rand sign needs to be added and where the rand sign is placed. The ICT tool was also used to help learners understand that they need to round off.
How did the teacher make use of the tool/s to better mathematical understanding? Local practice and PCK and PK	The teacher used the slide and tv to teach the lesso and give learners real-life examples which helped them understand it better. For example, chicken, washing powder, meat etc. These real-life exampl

	bettered their mathematical understanding becaus learners could relate to it and got excited to add u items they have seen before either at home or in t store.
To what extent is ICT used as a means of scaffolding? (conceptual practice)	Not much. The teacher walked around to assist those who were struggling. Learners worked on their mini whiteboards in pairs. The teacher scaffolded by doing some of the difficult questions on the board, she called learners up and they had to do the sum. If they made a mistake, they are self-corrected. No use of ICT.

Table 9: Observations for Teacher C

Questions	What was observed
What ICT tool/s was used in the mathematics lesson?	Smartboard Laptop YouTube Twinkl.com PowerPoint
What problems did learners have when it came to the understanding of mathematical concepts before ICT wa introduced? **Humanistic practice**, influencing the creative active knowledge of learners	The lesson was on fives, counting in fives especially backwards which learners seemed to struggle with at the beginning of the lesson when teacher first introduced the topic.
How has the ICT tool/s changed learner's level of understanding during lesson? PCK and PK vs learner understanding)	The tools helped learners count and practice the fives. Learners watched a video and followed along while counting, they mirrored the actions and words of the song and caught on while counting. The learners interacted with the slides made by the teacher and could fill in the missing numbers and do the "bunny hops".
How has learner's level of understanding changed after lesson?	Learners can successfully count in fives forwards and backwards. They could do an independent activity on counting in fives.
Does teacher make use of ICT skills taught to better conceptual understanding? How?	Yes. Teacher shows a wealth of knowledge on using ICT's in the classroom. The teacher made use of a variety of apps such as YouTube, Twinkl and PowerPoint and some smartboard features such as the timer, cutting out sections and colouring in on the board. These features were all used to better learners conceptual understanding of fives. Learners could successfully count backwards in fives after that.
How did the teacher make use of the tool/s to better mathematical understanding? Local practice and PCK and PK	The teacher made use of the tools to help learners successfully count backwards in fives by using the ICT tools.
To what extent is ICT used as a means of scaffolding?	The teacher scaffolds by demonstrating what nee to be done on the smartboard. She shows the first few examples and they answer it together and the

	she asks them to complete the rest alone. The learners who struggle, the teacher goes to them an assists them. She also does a few more examples the smartboard.

Table 10: Observations for Teacher D

5.4.4) Resources in teaching and learning

Through the CPD programmes teachers are trained to use various ICT devices for mathematics teaching and learning. Through the data we see that, not only make use of various tools and applications that they were trained on, but they also combine ICT with the concrete examples in their teaching and learning

5.4.4.1) ICT tools and applications

Figure 18 shows the devices teachers have been trained to use. 54% have been trained to use the boards like the Smartboard (22%) and the Interactive Whiteboard (IWB) (32%). These devices cannot be used alone and therefore teachers need to be trained to use a laptop, PC or even a cellphone or tablet in order to project the content. 21% of teachers are trained to use the laptop or PC, 18% for the cellphone and 5% are trained on the use of a tablet for teaching and learning. This tells us that although teachers are being trained to use the boards (Smartboard and IWB), they are not being trained to use the devices that need to connect to the boards. Without knowing how to use the laptop, PC, cellphone, or tablet, they might not be able to connect successfully to the boards and effectively make use of the boards. Figure 16 further shows us that although, 54% are trained to use the boards (Smartboard or IWB), only 36% of teachers actually make use of the boards in their classrooms. The main ICT tools used by this sample set of teachers is laptops or PCs (37%).

Figure 19 below depicts the number of teachers trained to use various devices, 26% of teachers are trained in using YouTube for integration however, figure 21 shows us that 46% of teachers use YouTube in their mathematics lessons, which tells us that although teachers are not trained for this application, they still make use of it for teaching and learning. When asked the question' "What ICT programmes have you been trained to use in mathematics lessons", 19% indicated that they use other programmes other than the ones listed by the researcher, these include Twinkl.com, Education.com, WhatsApp, Khanya Lab, Microsoft, Blue Book, MCO, Google Tech Facebook Group, Bitmoji Craze for Educators, Virtual

Library.

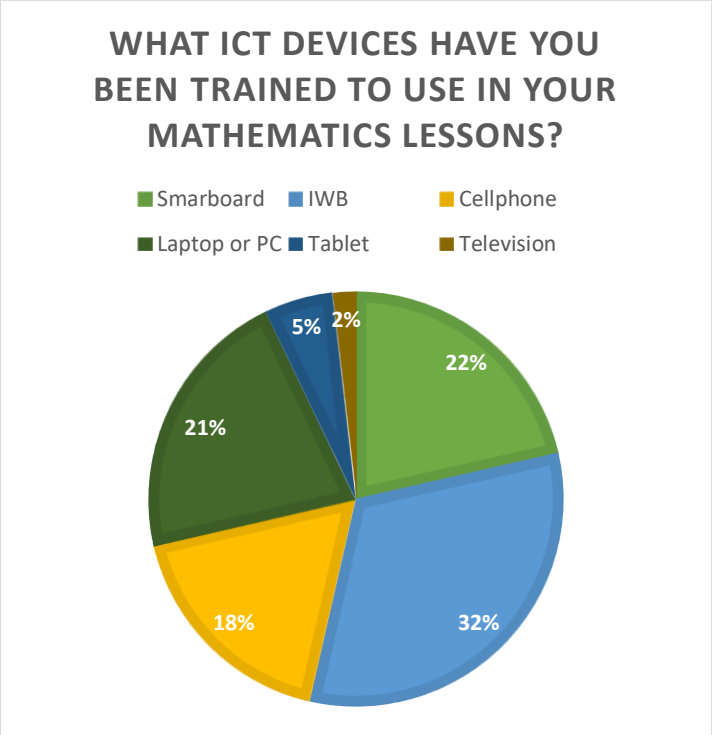

Figure 18: ICT devices teachers have been trained on

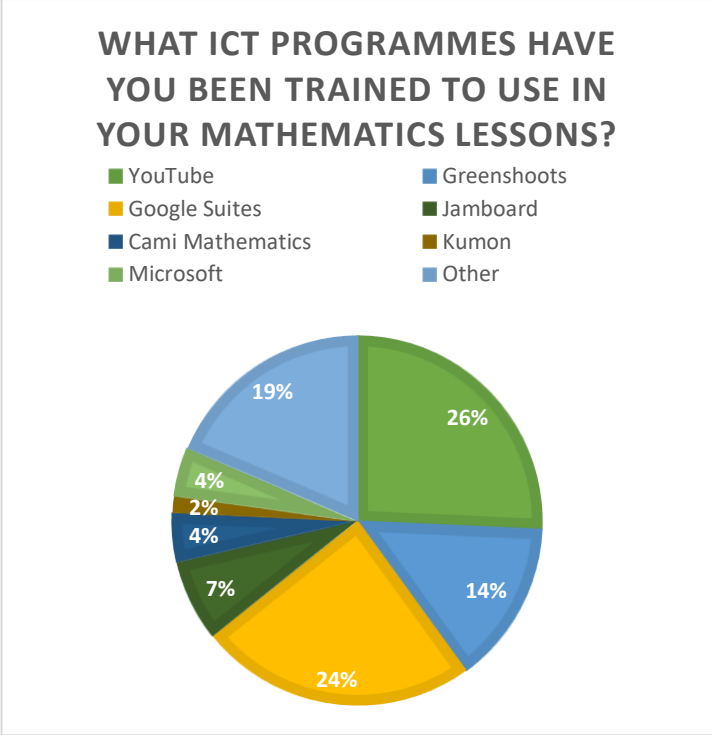

Figure 19: ICT apps and programmes teachers have been trained to use

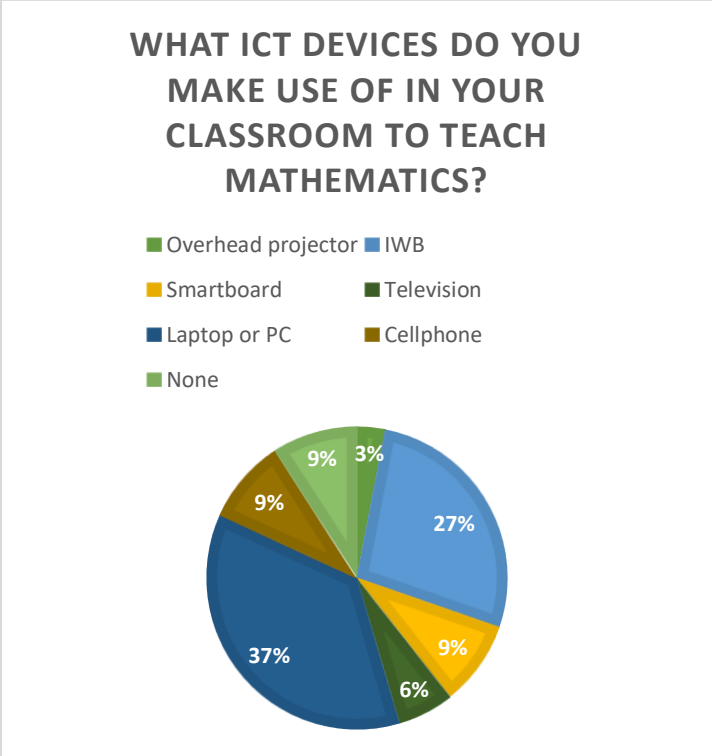

Figure 20: Devices teachers make use of for mathematics teaching and learning

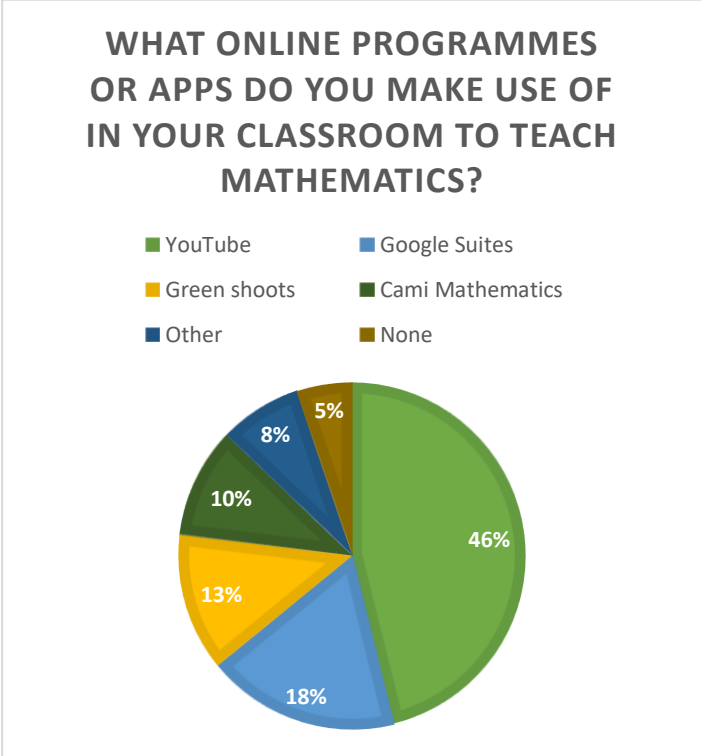

Figure 21: Apps and programmes teachers make use of for mathematics teaching and learning

5.4.4.2) Combining the concrete and the abstract for effective teaching and learning

One of the trends found in the data collection was the use of concrete resources in conjunction with the use of technology in the Foundation Phase classroom. During the classroom observation it was observed that Teacher A, B and C made use of concrete resources to enhance conceptual understanding. Teacher A made use of flash cards, mini whiteboards and counters (table 7), Teacher B used a mini whiteboards and learners writing pages on the mat (table 8) and Teacher C made use of mini whiteboards and her big whiteboard. Teacher A and C used these concrete resources as a means of scaffolding and to better learners understanding. The resources were used integrated with the ICT tools to better teaching and learning. However, Teacher B use the concrete resources throughout the lesson and the ICT tool was merely used as a board to project the consolidation sums. There was not much integration of the concrete and technological resources. During a discuss and follow-up semi-interview with Teacher B, she shared that her philosophy is to teach Foundation Phase learners using concrete examples and that children really enjoy the concrete examples as technology is a "novelty" to them.

5.4.5) Benefits and effectiveness of ICT

The teachers who were interviewed and observed all echoed similar sentiments about the effectiveness of ICT integration on their time. Teachers mentioned the fact that they reuse the slides and data for the next year or for revision which ultimately saves time and resources making teaching and learning more effective and meaningful. Teacher A and D shared that they download all their concept at home and then they are ready to teach during class time. Teacher C stated that she creates her own videos, learners can then watch it when she is not there, or they were absent. Teacher B shared that as a grade they have a shared room using Google Drive where they store all their concept and use when needed. "The nice thing with having the Smartboard and having the Google Drive and everything is that once you've got something you can keep it like now for instance, we developed a shared per room where we got lots of it like little game sites that we found.

5.4.6) Assessment

Teacher C, a grade 3 teacher mentioned in her interview that one of the benefits of ICT is for assessment, specifically the Grade three systemic tests. Teacher C stated that the Maths

Curriculum Online (MCO) helped prepare the teachers for the Grade 3 systemic tests as “it’s quite similar in the way they word the questions”.

5.5) Summary

In this chapter we looked at the data that was gathered through for the observations, interviews, and questionnaire responses. As discussed in chapter 4, the data was analyzed and categorized into various themes and sub-themes according to certain codes that were created from the patterns that emerged in the data. The themes that emerged were as follows, barriers to ICT integration, teacher perceptions towards ICT, implications for teaching and learning, resources for teaching and learning, benefits and effectiveness of ICT and assessments. Some of these themes had sub-themes which were analyzed in this chapter as well. This chapter illustrates these findings into graphs and tables and the findings will be discussed in the next chapter.

Chapter Six

Discussion, recommendations, and conclusion

6.1) Introduction

The main focus of this study is on the effects of CPD programmes on ICT integration in the Foundation Phase mathematics classroom. The study sought to answer the following research questions:

What are the effects of continuous professional development on ICT integration in Foundation Phase mathematics teaching and learning?

Sub questions:

- What is the nature of continuous professional development on ICT integration in the Foundation Phase?
- What impact does continuous professional development have on the integration of ICT in the teaching of mathematics in the Foundation Phase?
- What impact does continuous professional development have on the integration of ICT in the learning of mathematics in the Foundation Phase?
- To what extent does Foundation Phase ICT integration continuous professional development programmes impact teachers' Technological Pedagogical And Content Knowledge (TPACK)?

To answer these research questions both qualitative and quantitative methods were used. Using the qualitative tools; observations and semi-structured interviews; the researcher could analyze data from the perspective of the teachers using the interviews and to strength these findings the researcher was able to observe learners conceptual and mathematical understanding. Using the quantitative tool; the online questionnaire; the researcher was able to reach even more teachers and add their perspective on the CPD programmes they attended to the data of the four interviewed teachers.

This chapter systematically discusses the findings of the data that was analyzed in chapter

five. The themes found in the data collection process were establish in the previous chapter and will be used again to detail the findings. After discussing the various themes and sub-themes mentioned, the researcher has discussed the strengths and limitations of this study as well as the strengths and limitations of observations, interviews, and questionnaires. Furthermore, this chapter discusses recommendations made by the researcher, these recommendations were made for various stakeholders as well as recommendations for further studies. The researcher will then draw the research study to a close.

6.2) Discussion

The themes that will be discussed in this chapter are the barriers to integrating ICT into mathematics teaching and learning, teachers' perceptions towards ICT will be looked at specifically teacher confidence in using ICT and how teachers feel about the CPD programmes they attended. The implication of ICT on teaching and learning; one of the biggest themes; will be discussed in sub-themes namely, curriculum delivery, the effects of ICT integration on teaching and learning and conceptual and mathematical understanding. Within the theme of implication of ICT on teaching and learning, the resources in teaching and learning will be looked at in two parts namely, ICT tools and application as well as combining the concrete and the abstract for effective teaching and learning. Another theme that will be discussed is the benefits and effectiveness of ICT and the last theme that will be discussed is Assessment.

6.2.1) Barriers to integration

From the data analysis we see that 83% of teachers indicated that they make use of ICT in the classroom, the other 17% of the sample teachers indicated that they do not make use of ICT in the classroom (Figure 6). Lack of resources was the main reasons for teachers indicating that they never use ICT in their mathematics lessons. Not enough training and lack of confidence were stated by some of the teachers. One of the teachers specifically stated that there was "no training received for mathematics use", another stated that there was simply not enough time for technology integration in the mathematics lessons. As we can see from the above, the barriers to ICT integration does not only stem from lack of training. The sample teachers had some sort of ICT training in their careers but still do not make use of technology in their classrooms due to lack of access to technological resources, lack of confidence,

insufficient time and no further training is provided after an initial training.

Of the 83% of teachers (figure 6) who indicated that they do make use of ICT in the mathematics classroom, majority of those teachers stated that they do not use the methods taught in their professional development programmes in their lessons but rather other methods they were taught. This tells us that the methodologies taught in the CPD programmes are perhaps not realistic and programmed to suit the teachers way of teaching. This calls for a need to alter the current programmes to what is actually happening in the classroom and offer methods that teachers will find useful in the classroom.

Figure 7 shows us how often teachers are trained on ICT integration in mathematics. Most teachers (88%) indicated that they are trained sometimes. The other categories were very often and often, the sometimes tells us that they were not trained often. Considering that technology is everchanging, it is vital for teacher to be trained often. For continuous professional development to be continuous, it needs to be ongoing.

When asked whether the teachers use the applications and programmes taught in their practice, all interviewed teachers stated that they make use of these applications and programmes however, Teacher B stated that it is not always appropriate, so she does not make use of these applications and programmes daily like the others. The reasons for Teacher B's reluctance was because she feels Foundation Phase learners learn best using concrete materials and she merely uses ICT as an additional tool mostly for homework and enrichment activities. This can be seen as a barrier to ICT integration as it speaks to the hesitance of teachers to shift from traditional methods of teaching. This is commonly found amongst more experienced teachers as is the case with Teacher B who has been teaching for thirty-seven years.

One of the other barriers that came up in the teacher interviews was the financial barrier. As mentioned previously, lack of resources was a reason teachers indicated for not using ICT in their classrooms, but a common trend came up amongst teachers who make use of ICT, the lack of access to free "sites" or free online resources. Teacher C stated she would like to know of more online mathematics tools to use because it is "a bit of struggle" to find free apps. The teachers shared that their schools do not pay for membership or subscriptions to any sites and therefore they have resorted to looking for free websites to use. There are

several stakeholders that can be held accountable for this, firstly, the school and the departments of education both local and national should give teachers access to free sites and apps to use. For language the Foundation Phase teachers have the Jolly Phonics app which is free to download and use. There needs to be more free websites and applications for Foundation Phase mathematics. Something else that the above statement made by Teacher C tells us is that there is a need for the CPD programmes to include showing teachers free websites and applications to use for Foundation Phase mathematics. In the data collection teachers listed Twinkl.com, YouTube and Khan Academy as some of the online applications they make use of but they are limited to using those as it is free.

6.2.2) Teacher perceptions towards ICT

The next theme that emerged from the data was the perceptions of teachers. This theme discusses all aspects of the teachers feelings towards ICT that can impact on the success of ICT integration in the mathematics classroom. The first sub-theme that emerged was teacher confidence and the second was the teachers' feelings about the CPD programmes they attended.

6.2.2.1) Teachers epistemic stance towards integrating ICT into their practice

Lack of confidence was listed as one of the contributing factors towards teachers not integrating ICT into Foundation Phase mathematics teaching and learning. From the data (figure 8) we see that 92% of the teachers indicated that they are either very confident or somewhat confident with only 8% indicating that they are not confident, this is a good indicator as it shows that although it is a barrier for some, it is perhaps not the biggest barrier to the lack of successful ICT integration. Teachers A and C both shared the same sentiments about the CPD programmes making them more confident in using ICT in mathematics lessons. In the quantitative data, teachers were asked to rate their level of confidence towards various ICT tools in the mathematics. The ICT tools were tablets, cellphones, Smartboards, interactive whiteboards, and computers and/or laptops. For most of the tools (tablets, cellphones, Smartboards and interactive whiteboards) majority of the teachers indicated that they were between somewhat confident and very confident. For the use of computers and/or laptops, 68% indicated that they were very confident. From this data we see that teachers are more confident using computers and/or laptop for mathematics lessons. However, it is a narrow margin compared to the other tools. Overall, teacher confidence is between somewhat

and very confident and teachers could benefit from additional training on a variety of ICT tools to enable them to be "very confident" in using them for mathematics lessons. This is in line with what was found by Jones (2004), that there is a link between teacher competence and teacher confidence.

6.2.2.2) Teachers epistemological beliefs and efficacy towards the CPD programmes they attended

The teachers felt the ICT training was "helpful" and "informative". Teacher B offered a different perspective, she expressed that their "philosophy" is that they as a school or grade will look at what they were taught in the CPD programmes and decide whether they will use it or not, "we won't use something just because it's new, we will look and see does it make it better" and if it is going to add to what they are already doing. This perspective of Teacher B and by extension her school; tells us that teachers are selective with the skills they are taught in the CPD programmes and as mentioned earlier, the CPD programmes need to then be altered to suit the teacher and learner needs so that teachers do not feel the skills taught is not useful and choose not to make use of it. If teachers do not use what is taught, training is pointless.

Figure 14 shows that 84% of teachers attended an ICT integration course at the Cape Teaching and Leadership Institute (CTLI). This is a good indicator as it shows that many teachers are making use of the training programmes offered by the WCED. Of those teachers who attended the CTLI course/s only two teachers (illustrated in figure 15) indicated that they did not find the training course/s useful in helping them integrate ICT into their teaching. Although this is merely 10% of the sample, it shows that teachers do not feel the programmes offered by this departmental training institute is not sufficient.

6.2.3) Implications for teaching and learning

This theme looks at the implications the CPD programmes teachers attended had on mathematics teaching and learning. The sub-themes that emerged from the data were curriculum delivery, the effects of ICT integration on teaching and learning, conceptual and mathematical understanding, and the resources in teaching and learning both the concrete and the technological resources.

6.2.3.1) Curriculum delivery

From the data (figure 16) we see that 76% of teachers had something positive to say about the impact the CPD training had on their ability to deliver the mathematics curriculum. From the data in table 4 we see that the CPD programmes "enhanced" their understanding of mathematics and made delivery of the CAPS curriculum easier with special mention to the MCO (Maths Curriculum Online) programme. Teacher B stated that it added to the curriculum and opened more options for the teachers. Teacher D mentioned that it helped her teach in a more "holistic way" and that she has moved away from the traditional chalkboard to a fully digital and 'smart' teaching and learning approach. This contrasts with teacher B who still prefers the more traditional methods even after seeing the benefits of ICT on curriculum delivery.

Teachers felt that these programmes exposed them to different ways of teaching mathematics and broadened their "knowledge of number sense". It helped learners understand complex concepts better through the use of visuals. Teacher confidence was also mentioned as teachers spoke about their confidence and comfortability when delivering the mathematics curriculum due to their training. A common trend that was discovered in the survey data was that teachers found the training allowed them to deliver the mathematics curriculum and in more "interesting" and "entertaining" way and that it assisted them in creating more "diverse lessons plans". Overall, the sample teachers felt the CPD programmes positively impacted on their curriculum delivery.

6.2.3.2) The effects of ICT integration on Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge (PK)

In the Foundation Phase there are five content areas namely, Numbers, Operations and Relationships, Patterns, Functions and Algebra, Space and Shape, Measurement and Data Handling (DBE, 2011). When asked what content areas the CPD programmes covered (figure 17) 24% of the sample stated that their training covered mathematics in general meaning the training did not have a specific content area but rather spoke to mathematics in general. 48% covered Numbers, Operations and Relationships while 16% covered Space and Shape and 8% covered Patterns, Functions and Algebra. There were no teachers who attended a CPD programme on how to integrate ICT into Data Handling. From these statistics we see that there is a need to train teachers on integrating technology into the five content areas.

Teachers need to be shown methods and applications to integrate ICT into all five specific areas.

6.2.3.2.1) How did CPD assist teaching?

From the data in table 6 we see that teachers had a positive view on how the CPD programmes attended assist their teaching. Teacher A spoke of mentorship as she is the Foundation Phase Head of Department (HOD), the training allowed her to mentor her colleagues. Teachers B and C referred to the resources that can be used in their teaching and how effective it is and the positive impact it has on learners. Teacher D mentioned the benefit of technology during the COVID-19 pandemic and how the training allowed her to send videos of herself teaching to parents to ensure teaching and learning even when learners had to attended school every school day.

6.2.3.2.2) How did CPD assist learning?

All the interviewed teachers shared the same sentiments when it comes to technology bringing excitement to the classroom. Teacher C stated she found it motivates learners when ICT's are integrated into the mathematics lessons. Teacher A and D referred to how "meaningful" ICT can be, to assist learners in learning and how it helps bring across concepts in a better manner. Teacher B also shared how learners like technology however, she maintains that concrete objects are ideal and in her view for 21st century learners, technology is a "novelty" which they get bored of, so they much rather enjoy the concrete objects and examples.

Overall, we see from the data that the CPD programmes have indeed assisted in teaching and learning and that teachers feel the CPD programme benefitted them in the teaching of mathematics. There is however a gap in the CPD programmes, it does not cater specifically to each content area.

6.2.3.3) Conceptual and mathematical understanding

Through classroom observations the researcher was able to get a glimpse of whether the teachers could better learners conceptual and mathematical understanding through the use of ICT integration. In tables 7 – 10 we see that the teachers could successfully integrate ICT into teaching and learning and learners conceptual and mathematical understanding improved

through the use of the ICT tools and applications. However, in the case of Teacher B, learners conceptual understanding improved due to the use of concrete resources like her whiteboard and their pages they worked with on the mat. The teachers philosophy (as mentioned earlier) was based on using what is needed for the lesson and she felt the use of concrete examples and resources were better suited to teach that specific concept of division with triple digits. Teacher A and Teacher D also made use of concrete resources, Teacher A used flash cards and Teacher C the mini whiteboards Unlike Teacher B, the concrete resources used by teachers A and C were used in addition to ICT tools and were only used at the end of the lesson as a method of scaffolding for those who did not understand the concept. Through the observations, this researcher noticed that learners conceptual and mathematical understanding had improved but it was not entirely through the use of ICT. Teachers A, B and C are all Grade three teachers. Teacher D; a grade one teacher; was the only teacher observed who strictly used ICT in the lesson. She noted that she uses ICT in all her lessons, even handwriting.

6.2.4) Resources in teaching and learning

This theme looks at the various technological resources that teachers have been trained to use and are making use of in the Foundation Phase mathematics classroom. One of the sub-themes that rose from the data was the use of concrete resources and it can be used in conjunction with the abstract or technological resources for effective teaching and learning. These will be discussed below.

6.2.4.1) ICT tools and applications

Teachers were asked what devices and applications or programmes they have been trained to use in the mathematics classroom. 54% have been trained to use the boards like the Smartboard (22%) and the Interactive Whiteboard (IWB) (32%). These devices cannot be used alone and therefore teachers need to be trained to use a laptop, computer (PC) or even a cellphone or tablet in order to project the content. 21% of teachers are trained to use the laptop or PC, 18% for the cellphone and 5% are trained on the use of a tablet for teaching and learning. This tells us that although teachers are being trained to use the boards (Smartboard and IWB), they are not being trained to use the devices that need to connect to the boards. Without knowing how to use the laptop, PC, cellphone or tablet, they might not be able to connect successfully to the boards and effectively make use of the boards for

teaching and learning. Figure 18 further shows us that although, 54% are trained to use the boards (Smartboard or IWB), only 36% of teachers actually make use of the boards in their classrooms. This tells us that although teachers are trained to use the equipment, not all of them are able to put those skills into practice. According to the data, the main ICT tools used by this sample set of teachers are laptops or PCs (37%). Although laptops and PC's are valuable resources to use in the classroom, using them to show learners concepts proves to be quite difficult as the screens might not big enough for all to see and thus a Smartboard or IWB would be ideal to use with the laptop or PC to project the work to the learners.

Looking at ICT applications and programmes, the data tells us that 26% of teachers are trained in using YouTube for integration (figure 19) however, figure 21 shows us that 46% of teachers use YouTube in their mathematics lessons, which tells us that although teachers are not trained for this application, they still make use of it for teaching and learning. When asked the question' "What ICT programmes have you been trained to use in mathematics lessons", 19% indicated that they use other programmes other than the ones listed by the researcher, these include Twinkl.com, Education.com, WhatsApp, Khanya Lab, Microsoft, Blue Book, MCO, Google Tech Facebook Group, Bitmoji Craze for Educators, Virtual Library. We can see from this that teachers are making use of applications and programmes available to them that are free to use, all these programmes the teachers found themselves or heard about from peers they were not introduced to these applications and programmes through the CPD programmes. This reaffirms the need for CPD programmes to show teachers what free applications and programmes they can use.

6.2.4.2) Combining the concrete and the abstract for effective teaching and learning

One of the trends found in the data collection was the use of concrete resources in conjunction with the use of technology in the Foundation Phase classroom. During the classroom observation it was observed that Teacher A, B and C made use of concrete resources to enhance conceptual understanding. Teacher A made use of flash cards, mini whiteboards and counters (table 7), Teacher B used a mini whiteboards and learners writing pages on the mat (table 8) and Teacher C made use of mini whiteboards and her big whiteboard (Table 9). Teacher A and C used these concrete resources as a means of scaffolding and to better learners understanding. The resources were used integrated with the ICT tools to better teaching and learning. Richards (2005) tells us that in a child's formative years using both

the concrete and the abstract can be effective for teaching and learning, this is also the view of the three teachers mentioned above.

As mentioned previously, Teacher B use the concrete resources throughout the lesson and the ICT tool was merely used as a board to project the consolidation sums and the homework. There was not much integration of the concrete and technological resources. During a discuss and follow-up semi-structured interview with Teacher B, she shared that her philosophy is to teach Foundation Phase learners using concrete examples and that children really enjoy the concrete examples as technology is a "novelty" to them. This speaks to the hesitance of teachers to move from the traditional to the technological and modern. Teacher B stated that she only makes use of ICT where necessary and that she will not make use of ICT just because it is there but rather if it proves to add to learners learning. Research shows us that Teacher B is not the only one who has this outlook on ICT integration. Richards (2005) shows us that many researchers agree that the use of technology can be used provided that it is the most efficient and effective method and that there needs to be a link between the activities and the ICT tools used (Richards, 2005).

6.2.5) Benefits and effectiveness of ICT

There are many benefits already mentioned about ICT integration. One that is yet to be mentioned and that was echoed by all teachers was the effectiveness of ICT integration on their time. Teachers mentioned the fact that they reuse the slides and data for the next year or for revision which ultimately saves time and resources making teaching and learning more effective and meaningful. Teacher A and D shared that they download all their concept at home and then they are ready to teach during class time. Teacher C stated that she creates her own videos, learners can then watch it when she is not there, or they were absent, both Teacher C and D mentioned the benefit of these teaching videos during pandemic times. Teacher B shared that as a grade they have a shared room using Google Drive where they store all their concept and use when needed. "The nice thing with having the Smartboard and having the Google Drive and everything is that once you've got something you can keep it like now for instance, we developed a shared per room where we got lots of resources like little game sites that we found".

6.2.6) Assessments

Teacher C, a grade 3 teacher mentioned in her interview that one of the benefits of ICT is for assessment, specifically the Grade three systemic tests. Teacher C stated that the Maths Curriculum Online (MCO) helped prepare the teachers for the Grade 3 systemic tests as "it's quite similar in the way they word the questions". This shows us the value of ICT in preparing learners for assessments. One of the participant teachers mentioned that during the assessment time she makes use of the Smartboard to project the assessment script onto the board so she can go through the questions with learners, and they can all see the question she is referring to. This makes assessments more effective, and learners are able to better understand the questions.

6.3) Strengths and limitations

This study was limited to four primary schools with four teachers interviewed and four classrooms observed as well as 25 teachers in the questionnaire in the Metro South Education District. Therefore, the findings cannot be used to make generalizations about all Foundation Phase teachers in South Africa, as a very small sample of Foundation Phase teachers participated in this study. Overall, the data collection process went according to plan and moved quite swiftly however, two of the schools were not prepared for my visit even though we had discussed the observation and interviews and arranged the dates beforehand. At one of the schools, the observation had to be moved to a later period as learners had activities scheduled during the school day. The teacher was also reluctant to use technology in the classroom even though the researcher had informed the teacher and the school that the lesson had to integrate ICT.

The questionnaire data worked well as teachers could respond to questionnaire in their own time and wherever they pleased so this did not disrupt teaching time. However, the reasons for questionnaires being efficient is the same reason for it being quite a tedious process. Because teachers could do this in their own time, the researcher found herself having to remind teachers to complete the questionnaire as the responses came in quite slowly. This added additional time to the data collection process.

6.3.1) Strengths and limitations of observations

The observations allowed the researcher to see how teachers used their skills acquired to integration ICT into mathematics teaching and learning. The researcher could also identify

how these skills assisted teacher in bettering learners conceptual and mathematical understanding. This strengthened the study as the interviews and questionnaire gave the teachers perspectives, but the observations gave a realistic view of what happens in the classroom. Themes the researcher never thought of stemmed from the observation data. The limitations of observations are that the researcher only observed each class once and although this give insight into what happens in the classroom, the findings cannot be used to make generalizations for that specific class or Foundation Phase teachers in South Africa because the sample size is not big enough and risks giving an inaccurate depiction of Foundation Phase classrooms. Being in the class for one mathematics period does also not give us the full picture of what occurs daily.

6.3.2) Strengths and limitations of semi-structured interviews

The benefit of semi-structured interviews is that there is a set list of questions for participants to answer however, both the researcher and participant is allowed a realm of freedom to bring up anything they might find valuable, and the researcher is allowed to ask follow-up questions to mold the discussion. The interviews were a good follow-up after the observation. This helped the researcher understand the reasons for teacher using certain methods when teaching the lesson that was observed. One of the limitations to semi-structured interviews is that teachers have very busy schedules and there is a slight pressure on the interviewer to fit all the questions in during the short break time before teachers must go back to class. Like the observations, only four teachers were interviewed and again this does not give an accurate depiction of all Foundation Phase teachers perceptions.

6.3.3) Strengths and limitations of Questionnaires

The questionnaire was a good way of gathering many responses without having to physically go out and conduct interviews with teachers. The information sourced from the questionnaire made a huge difference to the study. The questionnaire does not disrupt class time and avoids any physical contact thus adhering to any COVID-19 protocols. The online platform allowed teachers to click the link and fill out the questionnaire in their own time and space. Teachers seemed to be keen to participate as they could fill the questionnaire whenever they pleased. However, teachers had to be reminded about the questionnaire as some of them forgot. Because teachers could complete the form at their own pace, the responses came in quite slowly.

6.3.4) Other strengths and limitations

The WCED permissions were granted without any hiccups however, the researcher had to do several follow up emails and calls to ensure the permissions were granted. The participants schools were very helpful and willing to accommodate me, this made the process easy. However, one of the participant schools and the teacher was not fully prepared for my visit and did not read my information sheet so they were not sure what was expected of them even though they gave permission and consent. This added to the researchers time at the school as the researcher needed to explain the reason for the visit. Overall, the data collection process went smoothly however, the questionnaire data took longer than expected to be returned.

6.4) Recommendations

This study analyzed the classroom observations and the responses of teachers in order to determining whether the CPD programmes attended by teachers assisted in the successful integration on ICT into mathematics teaching and learning in the Foundation Phase. The researcher makes the following recommendations.

6.4.1) Recommendations for CPD developers

The training of teachers should start at the pre-service level therefore, universities and colleges should train teachers on ICT integration and especially how to integrate ICT into mathematics. There should be a link between DBE and training colleges or universities as to what is required of teachers when using ICT in mathematics. For ‘continuous professional development’ to ‘continuous professional development’ it needs to be “continuous”. Therefore, teachers not only need to be trained when receiving a new ICT tool or introducing a new application, the training needs to occur on a continuous basis as technology is everchanging and therefore teachers skills need to be updated.

From the findings we see a need for CPD programmes to incorporate a section on free applications and websites for teachers to use. Integrated with the ICT mathematics training, presenters can introduce teachers to these free applications and websites as it is pointless having this wealth of knowledge but limited resources to make use of.

There should be various CPD programmes that train teachers on how to integrate ICT not

only into mathematics but into each specific content area within mathematics. There needs to be more programmes offered in Numbers, Operations and Relationships, Patterns, Functions and Algebra, Space and Shape, Measurement and Data Handling.

6.4.2) Recommendations for the education departments

Education departments (like the DBE and WCED) should liaise with teacher universities and colleges as to what the pre-service CPD programmes on ICT integration should entail. Education departments should provide more opportunities for teachers to upskill themselves on ICT integration by offering more CPD programmes on ICT integration that is specific to Foundation Phase mathematics. According to the departments policy, teachers are required to attend a certain amount of training in a cycle, however, this is not exclusive to ICT and as such teachers can attend any sort of programmes and choose not to attend an ICT training. This researcher proposes that ICT courses be compulsory meaning teachers must attend at least one ICT training programme in a cycle. The education departments should not only provide regular training programmes but should create or pay for subscriptions to applications and websites that are free for teachers to use in Foundation Phase mathematics so that teachers do not have limited options or do not have to resort to paying for the applications and websites themselves. Schools should be equipped with the necessary ICT tools and resources; it is pointless training teachers if there are not tools for teachers to use their new skills on. The education department needs to ensure that schools and teachers are using the ICT skills and tools taught in their classrooms.

6.4.3) Recommendations for schools

Primary schools should encourage teachers to upskill themselves by attending workshops and other CPD programmes, there should be a culture of wanting to develop oneself professionally at each school. Schools should also provide Foundation Phase teachers with CPD programmes additional to the programmes offered on ICT integration, this could take place after school for the phase to attend. Schools need to provide teachers with the necessary ICT tools and resources for teachers to make use of the skills they have been trained on. Schools also need to ensure that teachers are implementing these ICT skills and resources into their practice.

6.4.4) Recommendations for teachers

This study focuses on teachers' professional development and so we cannot neglect the role teachers have in their own development. Other than training offered by the various stakeholders, teachers should take measures to upskill themselves on ICT integration in Foundation Phase mathematics. It is then the role of the teacher to make use of these skills in the classroom to better mathematics teaching and learning. If teachers feel they need more training on a certain ICT skill or tool or perhaps lack confidence, they need to either sign up for a CPD programme offered by the education department or the school or they can make use of private measures in their own time for example using Google, YouTube or video tutorials to teach them.

6.4.5) Recommendations for further studies

This study focused on the Foundation Phase teachers' perceptions on how the CPD programmes they attended assisted them in successfully integrating ICT into mathematics teaching and learning. This researcher recommends that further studies be done on the impact these CPD programmes had on the results of learners. Looking at learners results before ICT integration and comparing this with the results after ICT was integrated into mathematics teaching and learning. This sort of study needs to be done over a period of time for findings to be valid and reliable and to draw an accurate conclusion as to whether ICT integration betters mathematical and conceptual understanding.

Another recommendation for further study would be to look the contents of the CPD programmes themselves and whether the content being taught to teachers is adequately preparing them for the classroom. As we saw in the findings, the training did not cover all mathematics content areas, further studies could look into how the five content areas are covered in the programmes and whether these programmes prepare teachers with the necessary skills to integrate ICT's into all Foundation Phase mathematics content areas.

6.5) Conclusion

As we can see from the above, the barriers to ICT integration does not only stem from lack of training. All the participant teachers had some sort of ICT CPD in their careers but still do not make use of technology in their classrooms due to various reasons. Teacher B shed light

on teacher hesitance and how there are teachers who prefer to make use of traditional methods of pedagogy as they see ICT as a "novelty" and that it does not hold the same educational value as concrete resources. This calls for a change in teachers' ideologies and their perceptions on using ICT in the classroom. Some of the main reasons for teachers not integrating ICT despite having attended CPD programmes were lack of technological resources, lack of confidence, not enough time and no further training provided after an initial training. In order for ICT to be successfully integrated into mathematics teaching and learning, teachers need to receive continuous training which will enable their skills and better their confidence as there is a link between teacher competence and confidence. Teachers also need to be trained on the various applications and websites to use especially free applications and websites. The programmes need to be tailored to suit both the teacher and learner needs so that teacher find the training relatable and will make sure of the skills taught. Finally, there is no use in training teachers to be knowledgeable and upskill them on ICT integration if the resources are not provided to integrate ICT. Schools should be ICT equipped with ICT tools and subscriptions to various online platforms in order for mathematics teaching and learning to be successfully integrated with technology.

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Appendices:

Appendix A: UWC ethical clearance letter

UNIVERSITY of the WESTERN CAPE

60 YEARS of hope, action & knowledge

12 August 2022

Miss C Senosi
School of Science and Mathematics Education (SMME)
Faculty of Education

HSSREC Reference Number:	HS22/5/34
Project Title:	Investigating the effects of continuous professional development on ICT integration in the classroom. The case of Foundation Phase mathematics teaching and learning.
Approval Period:	**11 August 2022 – 11 August 2025**

I hereby certify that the Humanities and Social Science Research Ethics Committee of the University of the Western Cape approved the methodology, and amendments to the ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report by 30 November each year for the duration of the project.

For permission to conduct research using student and/or staff data or to distribute research surveys/questionnaires please apply via:
https://sites.google.com/uwc.ac.za/permissionresearch/home

The permission letter must then be submitted to HSSREC for record keeping purposes.

The Committee must be informed of any serious adverse events and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Director: Research Development
University of the Western Cape
Private Bag X 17
Bellville 7535
Republic of South Africa
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

NHREC Registration Number: HSSREC-130416-049

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix B: WCED permission letter

Western Cape Government
Education

Directorate: Research

meshack.kanzi@westerncape.gov.za
Tel: +27 021 467 2350
Fax: 086 590 2282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20220823-5616
ENQUIRIES: Mr M Kanzi

Ms Chloé Senosi
35 Marlin Crescent
Strandfontein
7798

Dear Chloé Senosi,

RESEARCH PROPOSAL: INVESTIGATING THE EFFECTS OF CONTINUOUS PROFESSIONAL DEVELOPMENT ON ICT INTEGRATION IN THE CLASSROOM. THE CASE OF FOUNDATION PHASE MATHEMATICS TEACHING AND LEARNING.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **23 August 2022 till 30 September 2022.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Mr M Kanzi at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000

We wish you success in your research.

Kind regards,
Meshack Kanzi
Directorate: Research
DATE: 23 August 2022

Appendix C: Teacher interview

School:

Interview questions for teachers':

1. What grade do you teach?

2. How many years' experience do you have teaching Foundation Phase?

3. What ICT integration courses have you attended, or programmes have you been trainedon?

4. A. Have you either attended a course or upskilled yourself in a programme on ICTintegration in Foundation Phase Mathematics?

   B. If yes, which course which course (name of the course)If no, why not?

5. Did the course target a specific mathematics learning area? If so, which learning area?
   A. Numbers, operations, and relationships
   B. Patterns, Functions and Algebra
   C. Space and Shape
   D. Measurement
   E. Data Handling

6. How do you feel about the courses attended?

7. What skills were taught in the course/s you attended?

8. How did you use these skills to assist you in teaching?

9. How did you use these skills to assist you in learning?

10. How did the CPD training assist you in the delivery of the curriculum of mathematics?

11. What applications or programmes were taught that you could use to integrate ICT intomathematics?

12. Do you make use of the applications or programmes taught in your mathematicsclassroom? Motivate your answer.

    If yes, how?

    If no, why?

13. Other than the training, courses and programmes offered by the school and the Department of Education, what other measures have you taken to upskill your ability tointegrate ICT into your mathematics classroom? E.g. Microsoft Educator Center, YouTube, Google Teacher Center.

Appendix D: Classroom observation schedule

School:

Observation schedule

Grade: Teacher:

Number of learner's: Date:

Item:	Comments:
ICT tool:	
What ICT tool/s was used in the mathematics lesson?	
Learner's:	
What problems did learners have when it came to the understanding of mathematical concepts before ICT was introduced?	
How has the ICT tool/s mentioned above changed learner's level of understanding during lesson?	

How has learner's level of understanding changed after lesson?	
How did learners interact with the ICT tool?	
Teachers':	
Does teacher make use of ICT skills taught to better conceptual understanding? How?	

Was there evidence of CPD training on ICT integration during the lesson?	
How did the teacher make use of the tool/s to better mathematical understanding?	
Did the teacher successfully integration ICT into the mathematics classroom?	
To what extent is ICT used as a means of scaffolding?	

Appendix E: Questionnaire

(Formatting has been changed when converting from a Google Form to a MS Word document)

Continuous professional development in ICT integration of Foundation Phase mathematics

University of the Western Cape

MEd degree in Mathematics education

Research topic: Investigating the effects of continuous professional development on ICT integration in the classroom. The case of Foundation Phase mathematics teaching and learning.

Dear participant

Thank you for showing interest in participating in this survey.

Your responses to this survey will be used in my research thesis towards obtaining my masters degree in mathematics education. My research is about investigating the effects professional development programmes and whether they were effective in upskilling teachers on ICT (Information and Communications Technology) integration in Foundation Phase mathematics. This survey is only for teachers who have received training on ICT integration in Foundation Phase mathematics and therefore if you have not and answer no tothe first question you will be redirected to the end of the survey.

Please note that your participation in this survey is voluntary, anonymous, and confidential.The survey will take approximately five minutes to complete.

Any questions or concerns regarding this research, please contact:

The researcher: Chloé Senosi at 3642374@myuwc.ac.za or

The supervisor: Dr Simons mdsimons@uwc.ac.za

1. Have you received training or been part of a professional development programme on ICT integration in Foundation Phase mathematics? *

Mark only one oval.

- Yes *Skip to question 2*
- No

Consent

In order to do this survey consent must be given for responses to be used.

2. Do you give consent for your responses to be used in the research thesis? *

Mark only one oval.

- Yes *Skip to question 3*
- No

About you

The following section is about you as an educator

3. What grade do you teach? *

Mark only one oval.

- Gr
-
-
-

4. By the end of this year, how many years experience would you have teaching in the Foundation Phase? (Answer with number only) *

Continuous professional development

This section is about professional development programmesyou attended throughout your teaching career.

5. Have you received training or attended professional development programmes on integrating ICT into teaching and learning? *

Mark only one oval.

- ◯ Yes
- ◯ No

6. Have you received training or attended professional development programmes on integrating ICT into mathematics teaching and learning? *

Mark only one oval.

- ◯ Yes
- ◯ No

7. If yes, did the training target a specific mathematics learning area? Please choose from the learning areas below. If other, please state *

Mark only one oval.

- ◯ Numbers, operations, and relationships
- ◯ Patterns, functions, and algebra
- ◯ Space and Shape
- ◯ Measurement Data
- ◯ handling
- ◯ Other: _____

8. How often have you been trained on how to integrate ICT into mathematics? *

Mark only one oval.

- ◯ Very often
- ◯ Often
- ◯ Sometimes

9. Have you received ICT integration training from CTLI? (online or face-to-face) *

Mark only one oval.

- ◯ Yes
- ◯ No

10. If yes, was the training useful in helping you integrate ICT into your teaching?

Mark only one oval.

- ◯ Yes
- ◯ No

11. What ICT devices have you been trained to use in your mathematics lessons? (Check all applicable devices). (If other, please state). *

Check all that apply.

- ☐ Smartboard Interactive
- ☐ whiteboardTablet
- ☐ Cellphone
- ☐ Laptop or PC
- ☐ Other: _____

12. What ICT programmes have you been trained to use in your mathematics lessons? * (Check all applicable devices). (If other, please state).

Check all that apply.

- [ ] Greenshoots
- [ ] Cami Mathematics
- [ ] YouTube
- [ ] Google Suites (incl. slides, classroom etc.)
- [ ] Jamboard
- [ ] Kumon
- [ ] Mathletics
- [ ] Other: _____

Integrating ICT into your mathematics classroom

This section asks about your use of ICT in the mathematics classroom.

13. Do you integrate ICT into your mathematics lessons? *

Mark only one oval.

- ◯ Yes
- ◯ No

14. If yes, do you use the methods taught to you in the training or so you use othermethods to integrate ICT into mathematics lessons?

Mark only one oval.

- ◯ Yes, I use the methods I was taughtNo,
- ◯ I use other methods

15. If no, why not? (If other, please state)

Mark only one oval.

- ◯ Lack of resources available
- ◯ Not enough training
- ◯ Lack of confidence
- ◯ Other: _____

16. How often do you integrate ICT into your mathematics lessons? *

Mark only one oval.

- ◯ Very often
- ◯ Often
- ◯ Sometimes
- ◯ Never

17. How did the CPD training assist you in the delivery of the curriculum of mathematics? *

_____

_____

_____

_____

_____

Untitled Section

18. Think about the professional development programmes you attended. Do you use those skills taught to integrate ICT into the mathematics classroom *

Mark only one oval.

- Yes
- No

19. If no, why? (If other, please state)

Mark only one oval.

- I make use of other skills of integration
- I do not use ICT in the mathematics classroom
- Other: _____

20. How confident do you feel integrating ICT into mathematics teaching and learning *

Mark only one oval.

- Very confident
- Somewhat confidentNot
- confident at all

21. How would you describe your confidence to do the following: *

Mark only one oval per row.

	Very confident	Somewhat confident	Not confident at all
Using a smartboardfor mathematics lessons	◯	◯	◯
Using an interactive whiteboard for mathematics lessons	◯	◯	◯
Using a tablet for mathematics lessons	◯	◯	◯
Using a cellphone for mathematics lessons	◯	◯	◯
Using a computer or laptop for mathematics lessons	◯	◯	◯

22. What ICT devices do you make use of in your classroom to teach mathematics? (If other, please state) *

Mark only one oval.

- ◯ Smartboard Interactive
- ◯ whiteboardLaptop or PC
- ◯ Tablet
- ◯ Cell phone
- ◯ None
- ◯ Other: _____

23. What online programmes or apps do you make use of in your classroom to teach mathematics? (If other, please state) *

Mark only one oval.

- Green
- shoot
- s
- YouT
- ube
- Google Suites (example, Google
- Classroom)Jamboard
- Kum
- on
- Math
- letics
- Maths
- Budd
- y
- Cami
- Mathema
- ticsNone
- Other: _____

24. Other than training, courses and programmes offered by the school and DBE, what measures have you taken to upskill your ability to integrate ICT into the mathematics classroom? e.g Google Education courses etc. *

_____

_____

Comments

25. Are there any comments you would like to leave regarding continuous professionaldevelopment of teachers in ICT integration in Foundation Phase mathematics?

Thank you!

Thank you for taking the time to fill out the questionnaire and for being apart of this study :)