CHANGING PERCEPTIONS REGARDING THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES THROUGH SUBJECT-SPECIFIC PROFESSIONAL DEVELOPMENT: INSIGHTS FROM A SOUTH AFRICAN CASE STUDY

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Submitted in fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

CURRICULUM STUDIES

in the

SCHOOL OF EDUCATION STUDIES

at the

University of the Free State

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November 2021

DECLARATION

I, Molie Abittah Johannah Mafojane, declare that this thesis titled Changing perceptions regarding the use of information and communication technologies through subject specific professional development: Insights from a South African case study, submitted for the qualification Doctor of Philosophy at the University of the Free State, is my own independent work, done with the assistance and guidance of my promoter and co-promoter. It has not been submitted by me for any degree to any other university or faculty.

11 November 2021

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ABSTRACT

Limited technological and pedagogical content knowledge (TPACK) and unfavourable beliefs about teaching with ICT, hinder teachers' integration of Information and Communication Technologies (ICT) in their teaching. In this study I investigated the extent of change, across the intervention, of the ICT beliefs and practices perceived by the 86 South African Physical Sciences teachers who attended a year-long subject-specific short learning programme, which targeted TPACK development and was offered in a blended mode by a university.

This is a pragmatically conducted mixed-methods case study guided by the theoretical frameworks of the Technology Acceptance Model, the Theory of Planned Behaviour, and the SAMR (Substitution, Augmentation, Modification and Redefinition) framework. The pre- and post- 27-statement Likert-scale questionnaire data from the 53 participants who completed both, were analysed quantitatively both descriptively and statistically. This data guided the purposive sampling of 17 of these participants for engagement in audio-recorded semi-structured interviews, which were transcribed, coded and analysed qualitatively using NVivo. Additionally, the participants' descriptions and supporting photographic and video evidence of a lesson they submitted for assessment for the programme, also formed part of the qualitatively analysed data.

The findings suggest that the programme was effective at changing the beliefs and practices regarding ICT integration, of a considerable number of the teachers, who tended to perceive these changes as having multiple positive effects on the quality of their teaching practice. However, this was attained with considerable effort. Also, several school factors were found to inhibit the extent to which the participants were able to implement what they learnt in the professional development opportunity in their classrooms. Furthermore, several issues that had not been anticipated at the start of the programme arose as obstacles which reduced the efficacy of the programme for some of the participants.

Based on these findings, I make several recommendations for future iterations of this, or similar, programmes, as well as recommendations for teachers, principals and district officials, to enhance the likelihood of effective integration of ICT usage in subject teaching.

Key words: Change; Beliefs; Practices; Quality of teaching; Schools; Subject-specific; Goals; Professional Development

ACKNOWLEDGEMENTS

- I wish to acknowledge the specialised services of all the people who played a role in ensuring the success of this study. Most importantly, I wish to thank my promotor, Dr AE Stott, for her unwavering effort, positive encouragement and considerate way of providing advice, guidance and constructive criticisms. Dr Stott has furthermore provided statistical guidance and continued willingness to assist me when dealing with numbers. Thank you very much.

- Let me also thank my co-promotor, Professor Lynette Jacobs for her amazing support and motivation. In the midst of her busy schedule, she made time for me. She is simply the best!

- My appreciation and acknowledgement go to Prof. R Schall of the Department Mathematical Statistics and Actuarial Science, Faculty of Natural and Agricultural Sciences of the University of the Free State for the professional and detailed statistical analysis conducted for me.

- I would also like to thank the University of the Free State for providing the funds to complete this study. The support I received from University of the Free State included a bursary to complete my study. Furthermore, I would like to extend my gratitude to the language editor for editing this manuscript.

- I would also like to send my heartfelt appreciation to the Grade 10 Physical Sciences teachers from the selected schools in the Free State province who participated in this project by answering the questionnaires and participating in the interviews. Colleagues, thank you! More appreciation goes to the officials in the Free State Department of Education for authorising and registering this study.

- To my two boys, brothers (Moefakgae, Makgobola and Moretsele) and sisters (Mokgobo, Morakane and Ntswaki), relatives, special group of Physical Sciences colleagues: “Mpintji Tsa Science” and to the most special friend, Sibusisiwe Noxolo Manchu who supported me through this study I wish to extend the greatest of gratitude to you all. Sometimes you might not recognise the role you were playing in ensuring that I finished this work. Thank you all!

- Again, I would like to thank God Almighty who gave me the strength and courage to keep going with the study even when the road was not easy. Praise be to God Almighty.

DEDICATION

This study is dedicated to my late parents, Papi Price and Elizabeth Matsoai Chakane. I also dedicate it to my two boys, Relebohile and Motheletsi, brothers and sisters and all the grandchildren/great-grandchildren of the Chakane family.

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ACRONYMS

4IR	Fourth Industrial Revolution
ATU	Attitude towards behaviour
BIU	Behavioural Intention to Use
CAT	Computer Application Technology
CK	Content Knowledge
EACEA	Education, Audio-visual and Culture Executive Agency
ICILS	International Computer and Information Literacy Study
ICT	Information and communication technologies
IEB	Independent Examination Board
IS	Information System
ISTE	International Society for Technology Education
MST	Mathematics Science and Technology
NSC	National Senior Certificate
NDP	National Development Plan 2030
PBC	Perceived Behavioural Control
PCK	Pedagogical Content Knowledge
PEU	Perceived Ease of Use
PK	Pedagogical Knowledge
PU	Perceived Usefulness
SAMR	Substitution Augmentation Modification Redefinition
SLP	Short Learning Programme
SMT	School Management Team
SN	Subjective Norm
TAM	Technology Acceptance Model
TC	Technological Complexity
TCK	Technological Content Knowledge
TK	Technology Knowledge
TPACK	Technological Pedagogical Content Knowledge
TPB	Theory of Planned Behaviour
TPK	Technological Pedagogical Knowledge
TRA	Theory of Reasoned Action

CHAPTER 1: ORIENTATION OF THE STUDY

1.1 INTRODUCTION

The rise of "cyber-physical systems”, which offer people and machines a whole range of new capabilities, is termed as the Fourth Industrial Revolution (4IR). It symbolizes new ways in which technology is ingrained in society and even our human bodies (Davis 2016). It is transforming the way in which we live and work. Because of the complexity of the technologies driving the 4IR, and the breadth of their influence, all stakeholders must collaborate on novel governance measures (Yahya 2019). There is no disputing that 4IR technologies such as Artificial Intelligence and the Internet of Things can usher in a new era of economic growth, prosperity, and human well-being. Governments and institutions have a huge opportunity to use AI and digital platforms to improve people's lives, such as providing safe drinking water, changing education systems, and allowing people to identify themselves in order to access government grants, open bank accounts, and vote in elections (Smith 2019).

Many countries, including the United Kingdom (Livingstone 2012), Malaysia (Kannan, Sharma & Abdullah 2012), Turkey (Cavas, Cavas, Karaoglan & Kisla, 2009), and the Republic of Korea (RoK), were driven by the emergence of Information and Communication Technology (ICT) in all spheres of life at the turn of the 21st century, as well as the call for the creation of a knowledge society (Hwang, Yang & Kim, 2010). The *South African Action Plan for 2019 Towards the Realisation of Schooling 2030* (hereafter referred to as the DBE Action Plan) reflects this as well (Department of Basic Education, 2015), advancing South Africa's *National Development Plan 2030* (NDP) (National Planning Commission 2017). Educators, as key players in the education sector, must therefore integrate education with the 4IR, in which the line between man and machine blurs to allow for new possibilities. This requires educators to not only be aware of quickly changing technology and the unprecedented explosion of knowledge (Yahya 2019), but also to develop the skills needed to apply, manage, and interact with the new technology and with one another. Teachers would need to become more adaptable, increase their problem-solving skills, and be able to better communicate in both written and spoken form than ever before (Butler-Adam 2018).

ICT is considered by some as a possible solution to educational system difficulties in both developing and developed countries. It is also seen as a tool that could change education by improving the quality of learning and instruction. The use of ICT in the digital world produces new and innovative teaching models that broaden learning opportunities and prepare students for future careers (Sipilä 2014). Technology has been shown to be an important aspect in motivating educators to shape the future of education in novel and creative ways by serving as a catalyst for change (Yahya 2019). Educators must also be able to use ICT in the classroom to assist students in developing skills and the ability to perform effectively in a quickly changing and informed environment. Pedagogically sound methods that stimulate creative and active participatory learning, encourage knowledge exchange among learners, and equip students to participate in a community of lifelong learners, are all highly valued in the global competitiveness arena (Aguti 2016; Hunde & Tacconi 2013; Tedla 2012; Mwalongo 2011).

The National Planning Commission (2017) acknowledges the importance of information and communication technology in advancing South Africa as a country, stating that:

> *"Science and technology are key to equitable economic growth, because technological and scientific revolutions underpin economic advances, improvements in health systems, education and infrastructure" (National Planning Commission, 2017, p. 93).*

As a result, the South African government sees ICT as an integral part of its society and the crucial role it plays in educational development. After 1994, the Department of Education (DoE) stressed the importance of incorporating ICT into learning and teaching to remedy historical inequality. The DoE underlined the need to transform schools into centres for quality teaching and learning suited for the 21st century, and to enable learners to gain 21st century skills, as early as 2003, in response to the government's demand for schools to employ ICT (Jacobs, 2018).

The concepts of transformed learning and teaching via ICT were outlined in a later *White Paper on e-Education* (2004). *Criteria for Teacher Training and Professional Development in ICT* (2007) which was helpful in this study, since it provided the basis for recommendations for teacher training and professional development in ICT, as well as educator competencies within a developmental framework. Since then, the South African government has made it mandatory for schools to use ICT. The principal goal was to provide students with the skills they would need to participate in a global information economy (Mbatha 2015). The Department of Basic Education (DBE) and its partners are committed to enhancing teachers' professionalism, teaching abilities, subject knowledge, and computer literacy throughout their careers, as stated in Goal 16 of the DBE Action Plan (Department of Basic Education, 2015). The Integrated Strategic Planning Framework for Teacher Education and Development pledges to invest in digital technologies to support the implementation of the strategy, as outlined in the DBE Action Plan, resulting in the creation of the Professional Development Framework for Digital Learning (2018). The Professional Development Framework's major purpose was to provide professional development principles in order to develop competent educators who use ICT to improve teaching and learning, as well as leaders and support staff who can help educators to acquire digital learning competencies (Jacobs 2018).

1.2 RATIONALE AND STATEMENT OF THE PROBLEM

Jacobs (2018) suggests that a unified e-Learning strategy for the integration of technology in teaching and learning is essential in view of changes since the publication of the above-mentioned draft white paper, as well as the expanding ICT presence in schools. To inform such a strategy, she reported on the state of ICT and ICT integration in schools in the Free State province. According to her technical assessment, the majority of teachers in the Free State did not use ICT in their classes. This reinforces Roth's (2014) observation that, due to a number of barriers, many teachers around the world still do not use ICT to aid teaching and learning.

Issues that prevent teachers from implementing ICT in the classroom have been extensively researched. Among these are a lack of resources and support, a lack of expertise among teachers, and their attitudes towards ICT and education (Sherman & Howard 2012; Du Plessis & Webb 2012; Ramorola 2014). However, there is a scarcity of research on how to address these difficulties, notably in South Africa, and even less on in-service teachers (Sanchez-Garcia, Marcos, Gualin, Joaquin & Escribano 2013). While it is reasonable to expect (and hope) that graduating student teachers will have acquired the necessary skills and enthusiasm to use ICT effectively in teaching and learning, the bulk of teachers in South Africa was educated in the previous century (Holmqvist 2018). As a result, in-service teachers likely need to gain the necessary skills and confidence while on the job.

Despite the abundance of ICT workshops, research reveals that teachers' usage of ICT is mostly influenced by their beliefs on ICT and education (Shin, Han, & Kim 2014). It is thus suggested that to better understand teachers' use of ICT in their classrooms, we must first understand the beliefs that impact teachers' decisions to utilise technology or not, as well as how these beliefs may be modified if necessary (Kriek & Stols, 2010; Naicker 2010). Again, while student-teachers may be hopeful about utilising ICT to teach and learn because of their experiences at university, teachers who have been employed for a long time would not have had that opportunity. While thorough teacher training on how to use ICT is required in many educational programmes around the world (Donnelly, McGarr & O'Reilly 2011), training alone will not guarantee uptake in their classrooms. Furthermore, lab-style training alone in ICT skills has been shown to be ineffective (Ghavifekr & Rosdy 2015), implying that alternative training methods should be investigated. One possibility is to make use of subject-specific training.

Between February 2017 and September 2017, the University of the Free State offered a short learning programme (SLP) for Physical Sciences teachers, meant to improve their content knowledge (CK) while also developing their Technological Pedagogical Content Knowledge (TPACK). This was an attempt to use subject-specific content from the Further Education and Training school curriculum, through creating opportunities to experience ICT integration as a student. I have been involved in this programme from its inception. As a former teacher, subject advisor, and deputy chief education specialist for Physical Sciences, I have a passion for science and for innovative ways of teaching science that can benefit the learners. My passion led me to voluntarily attend the short learning programme sessions to equip myself with current innovative methods of teaching the subject. This involvement has made me aware of the opportunity to extend my involvement to a more rigorous study, which is presented in this document.

Physical Sciences teachers from all schools in the Motheo, Xhariep, and Lejweleputswa districts of the Free State[1] were invited to enrol for this programme. Each of the 86 teachers who chose to enrol received a tablet containing Grade 10 physical sciences software at the start of the course and was expected to engage with this content at home, in addition to attending face-to-face contact sessions. These sessions had the following format: two eight-hour technical sessions followed by 13 four-hour sessions, which alternated between compulsory pedagogical sessions and content sessions which were compulsory only for those scoring below 80% on a content test written in the previous session. Completion of the course was incentivised by the participants being allowed to keep the tablets, as well as the possibility of earning credits towards various qualifications, through a process of recognition of prior learning. To complete the course, the participants had to attend a specified minimum number of compulsory sessions and pass all six of the content tests, referred to above, as well as write a reflective essay, with supporting evidence, showing some ICT-usage in their teaching. The latter task was referred to as the final assessment task.

Other studies (Ratminingsih, Mahadewi., & Divayana, 2018; Pozo-Rico, T., Gilar-Corbi, R., Izquierdo, A. & Castejoin, J. (2020) have been about short interventions and focused on technical aspects of use of ICT (Bakir 2016; Shepherd et al. 2016; Tallvid 2016) – rather than of pedagogically sound use of ICT in teaching within a particular subject (Almerich, Orellana, Suárez-Rodríguez & García 2016; Koh & Chai 2016; Dorner & Kumar 2016). However, beliefs and practices do not change over a short period of time (Esfijani, A., & Zamani, B.E. (2020), and pedagogical skill with technology also takes time and direct attention to develop (Miheso & Mavhunga, 2020). This intervention, however, occurred across nine months, and was designed to specifically target the physical sciences pedagogical content knowledge of the teachers. The intervention was therefore considered worthy of study in an attempt to address the gap in the literature regarding whether it is possible to change teachers' beliefs and practices regarding ICT integration, where this is necessary, over a fairly long (nine month) subject-specific intervention.

[1] The Free State Province has five districts. In addition to the three mentioned in text, there is Fezile Dabi in the northern part of the province, and Thabo Mofutsanyane district in the eastern part of the province.

1.3 RESEARCH QUESTIONS

1.3.1 Main research question

The following is the main research question of this study:

What insights can be gained from a South African professional development opportunity aimed at changing (where necessary) teachers’ beliefs, practices and teaching quality related to use of information and communication technologies?

1.3.2 Specific research questions

To respond to the main research question, several secondary questions are posed in light of a South African professional development opportunity focused at strengthening Physical Sciences teachers' TPACK (as explained in detail in section 3.12):

1. How did the teachers’ perceptions regarding use of information and communication technologies change through the course of the professional development opportunity?

2. How were biographical and school factors related to the extent to which teachers’ perceptions changed through the course of the professional development opportunity regarding the use of information and communication technologies?

3. What practices did the teachers demonstrate in their use of information and communication technologies towards the end of the professional development opportunity?

4. What were the teachers’ perceptions regarding how the quality of teaching and learning in their classrooms was affected by their usage of information and communication technologies through the course of the professional development opportunity?

5. What issues arose during the professional development opportunity, and how did the teachers respond to these?

1.4 RESEARCH AIM

This research seeks to determine how a group of South African Physical Sciences teachers' beliefs, practices, and teaching quality in relation to the use of technology during teaching changed (or not) through experiencing subject-specific professional development aimed at improving technological pedagogical content knowledge.

The following sub-aims were explored to reach this aim:

- to understand how teachers' perceptions regarding the use of information and communication technologies changed through the course of the professional development opportunity;

- to determine how biographical and school factors related to the extent to which teachers' perceptions changed (where necessary) through the course of the professional development opportunity regarding the use of information and communication technologies;

- to investigate the practices displayed by teachers in their use of information and communication technologies towards the end of the professional development opportunity;

- to determine the teachers' perceptions regarding how the quality of teaching and learning in their classrooms was affected by their use of information and communication technologies through the course of the professional development opportunity;

- to investigate issues that arose during the professional development opportunity and how teachers responded to such issues.

1.5 THEORETICAL FRAMEWORK

This study is underpinned by the integration of the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw 1989) and the Theory of Planned Behaviour (TPB) (Ajzen 1991). These are only a few of the tested models that have been used in research on technology adoption. Above all, the TAM and TBP have existential support for being accurate and cost-effective in estimating the promotion of technology use in a variety of situations and technologies (Teo 2008).

TAM is the first model to take psychological aspects into account when predicting technology acceptance. The causal relationships between perceived usefulness, perceived ease of use, attitude toward ICT, and behavioural intention to use ICT are defined by TAM (Davis et al. 1989). The predicted general influence of technology use on job performance (process and outcome) is referred to as perceived usefulness, while the ease with which the technology may be used is referred to as perceived ease of use (Davis 1993).

The TAM model is an excellent predictor of ICT use (Teo 2012). To improve the TAM's external validity, Dishaw and Strong (1999) suggest that further studies should be done to understand the effects of technical and usage-context factors on user approval. This is supported by a meta-analysis of the TAM literature, which identified the non-inclusion of external factors as a flaw in TAM (Legris, Ingham & Collerette 2003).

The purpose of investigating external variables is to figure out how they influence behavioural intention to use ICT - in this example, ICT use in education. As a result, the theory of planned behaviour constructs were included in the theoretical framework I adopted for this study. TPB is an extensively utilised theory for clarifying and speculating about a variety of behaviours (d'Astous, Colbert & Montpetit 2005). Behavioural intentions, which are influenced by an attitude toward the behaviour, subjective norm, and perceived behavioural control, influence a person's behaviour (Ajzen 1991).

1.6 VALUE OF THE RESEARCH AND GAPS IDENTIFIED

1.6.1 Why teachers do not use technology

The South African government has stated that it intends to provide every school with a diverse range of exceptional communication services (DOE 2004). The DBE must acknowledge that no matter how much technology is available, or how sophisticated it is, it will not be implemented until teachers have the requisite skills, knowledge, attitudes, and pedagogy to incorporate it into the curriculum (George & Sanders (2017);

Govender 2012). According to Cox, Preston, and Kate (1999), the primary negative issue for teachers is difficulty in using ICT. In his research, Cuban (2001) found that many of the choices teachers make in the classroom are influenced by their ideas and values. He continues by saying that teachers' beliefs influence what and how they teach, as well as whether or not they support or reject new ideas. To fully comprehend teachers' incorporation of ICT into the classroom, we must first comprehend the ideas that impact their decisions to use or not to use technology (Kriek & Stols 2010). In the literature there are numerous examples of teachers' unfavourable attitudes, feelings, and opinions about using computers for instructional purposes (Stols 2008). This research differs from these studies in that it focuses on the extent of, and factors affecting, the change of teachers' beliefs and practices during a professional development opportunity, rather than on the status quo.

1.6.2 Lack of teacher training

Bladergroen, Chigona, Bytheway, Cox, Dumas and Van Zyl (2012) conducted a study to better understand the discourses surrounding education and technology as expressed by teachers in low-resource settings in South Africa. Extensive interviews with teachers from deprived schools in Cape Town, South Africa, were utilised to gather data for the study. The findings revealed that teachers recognise the importance of ICT in education and are eager to implement it. At the same time, they believe they lack the capacity and assistance to properly attain that goal (Bladergroen et al. 2012).

Nkula and Krauss (2014) investigated the complicated and difficult topic of ICT integration in schools. They discovered that many teachers lacked the essential computer skills to properly integrate ICT into the classroom. As a result, computers are often only reserved for special occasions, and they remain a source of fascination, dread, ambiguity, and mystery rather than a useful tool (Hew & Brush, 2007; Sherman & Howard 2012).

1.7 DEMARCATION OF THE STUDY

1.7.1 Scientific demarcation

"Curriculum Studies (CS) takes on the form of a verb, an action, a social practice, a private meaning, and a public hope," says Pinar (2010). As a discipline, CS has normative concerns, and works with the ontological questions of curriculum. The term "curriculum" refers to policy documents enacted by government agencies such as the Department of Basic Education in South Africa. These documents outline a country's educational aims and serve as the official curriculum. According to Reed, Gultig, and Adendorff (2012), in order to implement curriculum, the following elements are prioritised:

- Subjects taught in school and the knowledge gained from them;
- A set of guidelines for teaching knowledge in the classroom;
- Providing learners with the bare minimum of information, skills, and values; and
- Defining what curriculum designers and policymakers consider to be critical knowledge for students and society.

ICT is seen as a resource for reforming schooling, and a tool for whole-school development in South Africa by the Department of Basic Education and the Provincial Departments of Education (Department of Basic Education 2004). To meet the needs of all 21st century students, technology must be incorporated throughout the curriculum. Technology can be used to augment traditional lessons. The development of technology skills aimed at visualising and realising ideas and information, with a concentration on sketching and digital design, should be a priority. Technology can be used to implement a number of assessment procedures in the evaluation system (Mohanasundaram 2018). As a result, the world economy expects teaching professionals to enable pedagogical activities to develop “self-directed” learners who can qualify in professions that do not yet exist, and who are skilled in executing ICT-related tasks (Mukhari 2016). Therefore, professional development for teachers in the integration of technology is required. The findings of the study can enlighten policymakers and curriculum designers on how to construct teacher training in order to positively influence teachers' attitudes and practices about ICT use. As a result, my research can contribute to the body of knowledge in the field of curriculum studies and can be categorised as such.

1.7.2 Geographical demarcation

This study's empirical component is situated in the Free State province. The Free State is one of South Africa's nine provinces, and it is bordered by Lesotho, the Northern Cape, Eastern Cape, and Northwest provinces, as well as Gauteng. It includes both rural and urban areas. The province is divided into five education districts: Motheo, Xhariep, Thabo Mofutsanyane, Lejweleputswa, and Fezile Dabi, with teachers from all five districts participating in this study. Even though ICT integration is a global issue, the study will be limited to the Free State province. The reason for this is that I am based in the province, and the goal of the study is to see how Physical Sciences teachers' beliefs, practices, and teaching quality regarding the use of ICT change when they participate in subject-specific professional development opportunities based on technological pedagogical content knowledge (TPACK) principles in this province. However, there is a possibility that the findings may be of use on a nationwide scale.

1.8 LAYOUT OF CHAPTERS

The research will proceed as follows:

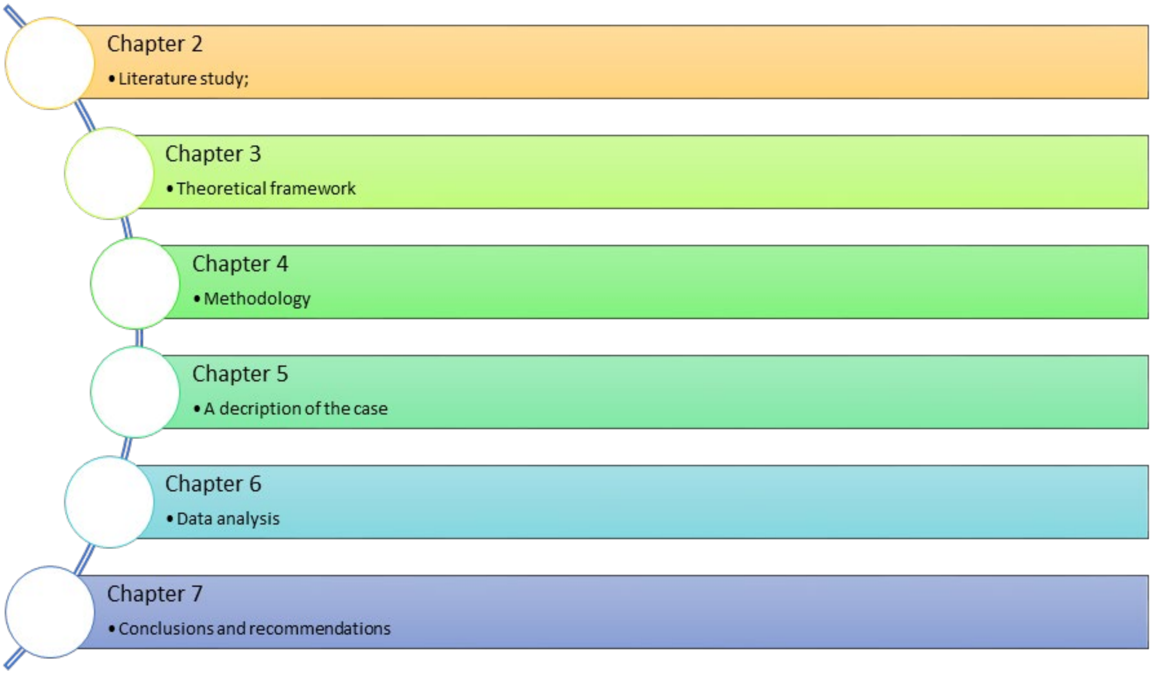


Figure 1-1: How the study unfolded

This thesis comprises of seven chapters.

Chapter 1: Orientation of the study: This chapter introduces the study, including its motivation and context, and also mentions the study's general research design and research questions.

Chapter 2: Literature review: This chapter reviews the literature on empirical studies on teacher beliefs and how they relate to behaviour changes in ICT use. The review also focuses on models that indicate how teachers' perceptions about ICT might be influenced by changing their practices. Apart from teacher beliefs, the review looked at additional factors that may influence changes in teacher beliefs and practices surrounding the use of ICT. The review concluded by examining empirical studies on ICT programmes intended to promote the use of ICT by changing teacher beliefs and practices. Another aspect attended to in the literature review was the aspects to consider when presenting such ICT training programmes in order to achieve their intended objective.

Chapter 3: Theoretical frameworks: In this chapter, the theoretical frameworks underpinning this study, and the rationale of these theoretical frameworks, are discussed. This chapter also discusses the ICT model and framework utilised in this study to determine the teachers' ICT usage level in their classrooms, and to evaluate the educators' final assessment task.

Chapter 4: Research methodology: This chapter explains the research techniques and research designs employed in this study. This chapter includes a description of the research tools and data collection techniques, as well as an explanation of the data analysis procedures employed in the study.

Chapter 5: Description of the case: In this chapter, a full description, content, and context of the SLP intended to promote ICT usage by changing beliefs and practices of Grade 10 Physical Sciences teachers in the Free State province are discussed. The chapter further presents a discussion of the context of 29 teachers, and the final assessment tasks of three teachers.

Chapter 6: Analysis and interpretation: In this chapter, data obtained using various tools, as well as their interpretation and analysis, are given to provide answers to the study's research questions.

Chapter 7: Conclusion and recommendations: This chapter focuses on the study's conclusions and recommendations, and draws together the literature, the theoretical framework, and the findings.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Learning and teaching with technology are becoming more common. However, full integration of technology is not simple, even though it is part of a change that needs to happen in education (Berrett, Murphy, & Sullivan 2012; Inan & Lowther 2010a). This is seen in how technology use varies in schools. Some teachers effectively integrate ICT to teach, while many others do not (Jacobs, 2018; Spector 2010). Factors such as the availability of ICT equipment, the school, and the teacher, and how well teachers are trained, plays a prominent role in how ICT can be effectively integrated (Afshari, Abu Bakar, Su Luan, Abu Samah & Say Fooi 2009; Arntzen & Krug 2011; Kimmons, Miller, Amador, Desjardins & Hall 2015; Tondeur, Hermans, Valcke & Van Braak 2008).

Educating teachers on how to use ICT effectively in the classroom is a prerequisite to successfully teach contemporary learners, known as the 'Net Generation'. They are generally expected to be creative and innovative, develop the ability to think critically and solve problems, be global citizens, technology literate and lifelong learners (Mathipa & Mukhari 2014). Teacher skills on how to effectively integrate ICT in the classroom is a great need, according to studies in South Africa and other developing countries (Mbatha 2015). This suggests that teachers' training should focus on pedagogical issues of ICT integration in the classroom rather than on ICT skills only (Shiboko 2015). This focus on pedagogical issues should improve pedagogical beliefs, knowledge, and ICT skills, which in turn should increase teacher usage, which might in turn change teachers' attitudes and beliefs regarding ICT usage (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur 2012).

In the first chapter, I provided the introduction and rationale for the study, and stated the research questions that guided the study. In this chapter, I review the literature on teacher beliefs and its link with a change in practices, especially related to the use of ICT in the classroom. Also included are the factors affecting teachers' change in beliefs and practices regarding the use of ICT, the programmes intended to promote the use of ICT by changing beliefs and practices, as well as aspects to consider when conducting an ICT training programme to change beliefs and practices regarding the use of ICT.

2.2 EDUCATIONAL BELIEFS HELD BY TEACHERS

Teachers' beliefs are a favourite topic in research in education. It is not easy to describe teachers' beliefs in an unquestionable way, especially when investigating the various ways in which such beliefs are described in literature (e.g., Ertmer 2005; Tondeur, van Braak, & Valcke 2008). Petko (2012) describes belief "as an independent element of knowledge that an individual considers true and important about a specific subject or context and is bound up with a person's past or history". Petko (2012) further states that it is difficult to change beliefs once they have been adopted. For instance, if teachers have a strong belief that teaching is effective when traditional teacher-centred approaches are used in a specific subject, it might not be easy to influence them to use ICT during their teaching. Fives and Buehl (2012) identified general characteristics that describe teachers' beliefs: a) implicit and explicit nature of beliefs b) core and peripheral nature, and c) contextual activation.

The distinction between implicit and explicit nature refers to whether individuals are conscious of the beliefs they hold (Fives & Buehl 2012). An implicit view suggests that teachers' behaviour is guided by beliefs, and beliefs also refine how teachers interpret their experiences of teaching without even being aware of it (Fives & Buehl 2012). Such beliefs cannot be controlled by teachers and are not influenced by teachers' reflecting on what they do (Fives & Buehl 2012). On the other hand, there is the explicit view of looking at the beliefs that teachers hold (Rimm-Kaufman, Storm, Sawyer, Pianta & LaParo 2006). According to Dewey (1986), such beliefs demand both mental and practical commitment. Dewey (1986) states that "beliefs …involve precisely this commitment and consequently sooner or later they demand our investigation to find out upon what ground they rest" (p. 117). This viewpoint on beliefs highlights the explicit nature of beliefs that must be justified before they can be maintained (Fives & Buehl 2012).

Core beliefs are not easy to change, as they connect to other beliefs. These beliefs are established over a long period of time (Ertmer 2005). On the other hand, peripheral beliefs are more recently established beliefs that can easily be changed (Five & Gill 2015). In this context such beliefs include ideas about how to manage the classroom and practices, and learners (La Paro, Siepak, & Scott-Little 2009).

In describing beliefs, another issue to consider is whether they are regarded as positioned in specific conditions, or if they can be applied to other situations. The research in this area focuses on the extent of influence of the beliefs held by teachers across varying situations. For example, a teacher who holds a firm belief about the feasibility of learning through inquiry, may change this belief when the teacher experiences a particular condition in which inquiry learning does not occur, such as the lack of resources, or learners' prior knowledge before they learn new information (Fives & Buehl 2012).

Ertmer (1999, 2005) identifies three categories of beliefs that teachers hold regarding how ICT can effectively be used to teach. The first is as a supplement to the curriculum, for developing learners' skills and motivating them, secondly as a support structure to the current curriculum, where technology is used to teach content, promote teamwork among partners and detail thinking, and thirdly as a tool to implement curriculum transformed to meet learners' needs.

Prestridge (2012) identifies four pedagogical beliefs in relation to the use of technology. He mentions developing technical skills when a device is used (use of an interactive whiteboard, keyboard, mouse etc.), performing functional activities (e.g. use of a text processor), performing activities that expand and augment the current syllabus, and promoting and exploring new sections of learning and teaching. The same categorisation is suggested by Mama and Hennessy (2013), but a different type of belief, called "subversive" belief, which incorporates the anxiety that technology frequently create among teachers, is added.

The discussions indicate that teachers' belief systems comprise various characteristics which are related to learning and teaching beliefs (Ertmer & Ottenbreit-Leftwich 2010; & Hermans et al. 2008).

2.3 TEACHER ICT BELIEFS AND THEIR IMPACT ON PEDAGOGY

The nature of the ICT beliefs held by a teacher influences his or her decision to adopt ICT or not (Khader 2012). Petko (2012) differentiates between positive and negative beliefs about ICT. He asserts that "common positive ICT beliefs relate to improved learning processes and better learning success, the promotion of independence and collaboration, improved work efficiency and effectiveness, improved learner motivation, the importance of computer skills in society, and diverse benefits of particular ICT functions" (Petko, 2012, p.1353).

Teachers who hold positive ICT beliefs are more likely than those with negative beliefs to adopt ICT to fulfil their teaching needs if all external conditions are favourable. They are also likely to try to expand their competencies to better effectiveness and efficiency (Mbatha 2015). Davis (2004) argues that teachers more easily adopt computers in their teaching after having had successful experiences, which led them to self-discover the various benefits of ICT. By so doing, opportunities to use computers in diverse ways are opened. When technology provides teachers with what traditional methods cannot, or what teachers cannot do for themselves, teachers are likely to adapt to technology more easily. Sabzian and Gilakjani (2013) further indicate that teachers' levels of competence with ICT, learning processes, and their theory and how they perceive teaching, play major roles in how they encourage themselves to use ICT and how they implement ICT in their classrooms.

According to Petko (2012. p. 1353):

> *Common negative ICT beliefs relate to the primary importance of hands-on experience, the risks of isolation in a virtual world and digital over-stimulation, questions about the quality of online media, media-associated disciplinary problems, lack of practicability or simply lack of priority for using ICTs in the classroom.*

Davis (2004) suggests that negative ICT beliefs are associated with low use, as predicted by the technology acceptance model (TAM). Poor adoption of ICT is strongly influenced by negative ICT beliefs, even where ICT resources are available. Teachers' willingness to use ICT for different tasks that may make optimal use of technology is also influenced by such beliefs. Teachers with negative beliefs about ICT tend to avoid the use of technology, because they see technology as adding on to their already heavy everyday teaching load. This could be influenced by a lack of technological skills that still have to be obtained before ICT can be used in the classroom.

Teachers who hold positive ICT beliefs will possibly encourage other teachers to use ICT during teaching, as opposed to the traditional way of teaching. Teachers who hold negative beliefs about ICT have the perception that technology can be used up to a certain point in education (Mbatha 2015).

2.4 THE RELATIONSHIP BETWEEN TEACHERS' PEDAGOGICAL BELIEFS AND ICT USAGE

According to Teo, Chai, Hung and Lee (2008), teachers' preferred ways of teaching are based on their pedagogical beliefs. Integration of technology refers to practices and perceptions associated with the use of technology. According to Lui (2011), the teaching methods applied when technology is used can influence teachers' pedagogical beliefs regarding how technology can be used. Technology integration depends heavily on the pedagogical beliefs that teachers hold.

Kagan (1992) investigated whether newly acquired technological skills, knowledge and technological experiences are relevant to teachers' pedagogical beliefs. It is suggested by researchers that when teachers use technology over a long period, their classroom practices change, and they eventually endorse learner-centred beliefs to a greater extent (e.g. Matzen & Edmunds, 2007). Teachers might not all use technology. The non-usage of technology could be affected by multiple external factors to do with conditions of teaching and these can affect internal teacher attitudes, beliefs and practices such as motivations, skills, self-efficacy, knowledge, emotions, and experiences (Stoll 1999). Additionally, teachers' views on how to become more effective inform their actions in integrating technology into their teaching practices and expanding their methods of instruction (Ertmer et al. 2015).

Learner-centred and teacher-centred beliefs are two classifications of teacher pedagogical beliefs in educational technology (Deng, Chai, Tsai & Lee 2014). Teachers with learner-centred beliefs tend to emphasise individual learner interests and needs (Mayer 2003), and embrace instructional methods commonly connected with constructivism (Deng et al. 2014). Brown (2008) further emphasises that teachers with learner-centred beliefs help learners to make imperative determinations and valuable decisions about content and the teaching methods relevant to their own lives. It also gives learners ownership over their learning. The teacher assumes the role of a facilitator who helps learners achieve their goals (Ahmed 2013). Teacher-centred beliefs, on the other hand, tend to lead to discipline, content knowledge, and a high moral standard (Mayer 2003), and are generally associated with behaviourism (Deng et al. 2014). The teacher serves as the only specialist in a highly disciplined classroom and is authoritative, overseeing the learning process (Mayer 2003). Teachers are the main knowledge evaluators, and there is no room for learners to develop themselves (Ahmed 2013).

Teachers with robust constructivist pedagogical views are more likely to integrate technology during teaching than teachers with traditional pedagogical beliefs, according to Ertmer et al. (2015) and Lui (2011). Such teachers tend to use technology more regularly, and have a tendency to use it in a more learner-centred manner, for example affording learners the opportunity to choose and self-direct how they use the available technology resources, compared to teachers with traditional pedagogical beliefs (Becker 2000). Teaching methods, when using technology, are influenced by teachers' pedagogical beliefs about how to integrate technology (Ertmer et al. 2012).

2.5 THE RELATIONSHIP BETWEEN BELIEFS AND PRACTICE

Tondeur, Van Braak, Ertmer and Ottenbreit-Leftwich (2017) observed that teachers' educational practices are aligned to their pedagogical beliefs. A study by Donnelly, McGarr, and O'Reilly (2011) found that teachers with "contented traditionalist beliefs saw no need to use technology when traditional practices continue to work" (p. 1478). Therefore, they tended not use it. Another study by Lim and Chan (2007) found that teachers believed that technology was unnecessary in teaching and learning, since a chalkboard served their educational goals just as well. This is because their personal educational experiences were largely through direct teaching.

A study conducted by Pedersen and Liu (2003) indicates a close relationship between practices and beliefs. In their study, a teacher teaching fourth grade classified her beliefs as being learner-centred. She used technology to encourage real world, authentic applications: "I try to give my learners hands-on things, things that have a real-life application, and I think that technology just fits in with that"' (p. 431). Lim and Chan (2007) further support the above when they indicate that teachers who are orientated within the constructivist practices use technology as a problem-solving tool. These studies suggest that the beliefs that teachers hold about teaching and learning are related to the way they use technology in their classrooms (Tondeur et al., 2017).

However, in the existing literature there is contradiction between beliefs and teaching activities (Steyn & Van Greunen 2014). For example, Sandholtz and Reilly (2004) noted that even if teachers have constructivist beliefs, this is not a guarantee that they will implement those beliefs into their classroom practices. Ertmer et al. (2012) agree with this notion. Some teachers require learners to do drills and practice exercises that are related to representational use and their own traditional pedagogical beliefs (Lui 2011). This suggests that even though teachers may have constructivist pedagogical beliefs, they may still use technology in a traditional way (Steyn & Van Greunen 2014).

There are different reasons for these inconsistencies in practices and beliefs in the literature, mainly the influence of outside factors. For instance, pressure from parents may persuade teachers to rather use lecture-based instruction (Chen 2008; Li 2007).

2.6 HOW AND WHEN CAN TEACHERS' BELIEFS CHANGE?

Change in beliefs is conceptualised as a continuous item of professional teacher development. The study on how belief change occurs in practicing and pre-service teachers is grouped into three categories: change in beliefs for pre-service teachers (typically related to teacher preparation), change in beliefs for practicing teachers (typically related to professional development), and the development of belief change (distinct changes experienced across a period of years and experiences) (Fives & Buehl 2012).

2.6.1 Change in beliefs of pre-service teachers

Changes in the beliefs of pre-service teachers have been shown to be affected by field experience (e.g. Brownlee & Chak 2007; Fives, Hamman & Olivarez 2007; Knoblauch & Hoy 2008) and academic work (e.g. Doppen 2007; Isikoglu 2008; Olson & Jimenez-Silva 2008). Student teachers reflect on their academic work, or during teaching practice, in this type of research. The reflection of student teachers on their academic work is a standard practice and a requirement in their educational journey. The outcome of this practice does not usually produce the desired change in pre-service teachers' beliefs (Kyles & Olafson 2008).

According to Yerrick and Hoving (2003), some pre-service teachers' beliefs about teaching science to low-performing learners changed after they enrolled in a field-based science inquiry course. There was a transition from a self-centred practice to a learner-centred practice for pre-service teachers who adjusted their beliefs about how to teach science to low-performing learners. They also reflected on their practice and were identified as producers. Reproducers, on the other hand, were identified as those that were unable to build their own learning experiences, and they became defensive in their actions and choices in written and oral reflections (Yerrick & Hoving 2003).

Reflecting on belief change is vital and meaningful, and this is supported by prior research (e.g. Yerrick & Hoving 2003; Kyles & Olafson 2008; Fives & Buehl 2012). It is vital to remember that structured reflection is required for certification and supervised degree elements. Fives and Buehl (2012) further mention that reflection during pre-service training has the power to bring about a shift in belief, so it must be further emphasised after the pre-service phase of a teacher's career.

2.6.2 Change in beliefs of practicing teachers

Several researchers have examined how teachers' attitudes have changed because of in-service programmes designed to change their beliefs and practices. Regardless of the lengths of the programmes, whether over a few hours or over a lengthy period of time, Beswick (2007–2008) and Magos (2006) found varying belief changes after the professional development opportunity. However, according to Magos (2006), general or overarching attitudes are much more difficult to change than content-related beliefs (Beswick 2007–2008).

A professional development opportunity must have clear targets and goals to be successful in influencing the beliefs of practicing teachers (Beswick 2007–2008). In this study, sixty-one teachers participated in a year-long in-service programme to assist them to introduce posing questions into their primary mathematics classrooms. Teachers read about, argued, implemented, and reflected on the numerous ways the problem-posing technique could be transferred and used in their own teaching practices. They established a professional learning community in which they shared their ideas, challenges, and triumphs (Barlow & Cates 2006).

The discussion in paragraph 2.6.1 and the finding by Barlow and Cates (2006) show that pre-service and practicing teachers' beliefs may change in response to specific experiences, and throughout their careers. It is noteworthy that change in teachers' beliefs and practices is indeed shaped by a multitude of factors, including individual and contextual contexts, the length and type of the experience, and the target beliefs (Fives & Buehl 2012). Ertmer et al. (2012) suggest that further research is done on how teacher professional development might change beliefs and practices.

2.6.3 How belief change develops

In their qualitative study, Levin and Wadmany (2006) investigated the practices and attitudes of six Israeli fourth to sixth-grade teachers with three to eight years of teaching experience during the first three years of introducing a rich technology-environment. It is worth emphasising that over this time, teachers' beliefs on teaching and learning progressed from superficial to complex and comprehensive. For five of the six teachers, there was a noticeable shift in their beliefs and classroom methods. Although there were adjustments, these did not represent significant shifts in knowledge. Three years later, three teachers who started the study with transmission conceptions of teaching and behavioural conceptions of learning had mixed perspectives on learning that contained cognitive constructive and behavioural ideas. They continued with the transmission model of teaching, emphasising learner comprehension over topic coverage. Rather than making integrated qualitative improvements, these teachers added to their previous beliefs, resulting in a shift in how they view learning.

Brownlee (2003) performed another study in which 11 groups of primary school teachers were polled at the beginning and end of their teacher education programme. These teachers were interviewed again after their third year of teaching, about their beliefs about personal epistemology. During each interview, the participants' perceptions of the role of experts in knowledge construction and the nature of knowledge changed noticeably. Most respondents expressed mixed views. Participants indicated constructivist concepts at the end of the programme, and constructivist beliefs were reported after three years of teaching, but constructive beliefs were less at the end. Pre-service teachers, in contrast to practicing teachers in this study, started with less cohesive belief systems throughout their preparation time, and this transformation was fragile and at risk of being lost in the face of classroom practice realities, according to Levin and Wadmany (2006). They started with less cohesive belief perspectives, and this shift was fragile and at risk of being lost in the face of classroom practice realities.

Crawford (2004) found that a novice teacher exposed to the constructivist paradigm during her teacher education programme, changed from these practices to a teacher-centred approach once she started teaching. This is an example of the potential vulnerability of inexperienced teachers' knowledge and beliefs.

2.7 PREDICTING TEACHER CHANGE IN BELIEFS AND PRACTICES THROUGH PROFESSIONAL DEVELOPMENT

Pedagogical beliefs influence teachers' pedagogical choices on whether and how to employ technology in the classroom (Deng et al. 2014). Furthermore, how ICT will be used in their classrooms is heavily influenced by teachers' attitudes and perceptions (Scherer, Tondeur, & Baran (2018); Naicker 2010; Martinovic & Zhang 2012). According to Cox & Marshall (in Naicker 2010), professional development should address teacher attitudes and perceptions concerning technology usage, as well as question teachers' beliefs about learning and teaching. Professional development should encourage teachers to question and modify their pre-existing pedagogical beliefs (Prestridge 2012).

Although teachers' professional development differs greatly in substance and format, most professional development programmes have the same goal in mind: to develop appropriate professional practices and beliefs and to change these if existing ideas and practices are inappropriate. Even though professional development programmes execute systematic efforts to influence teachers' beliefs and attitudes, classroom practices, and learners' learning outcomes, many professional development programmes fail to modify teacher beliefs and practices (Guskey 2002).

2.7.1 Model for teacher change

Leaders in professional development believe that improving teachers' beliefs and attitudes will result in specific changes in their classroom behaviour and procedures, leading to improved learner performance. As a result, they regularly try to persuade teachers to change their minds about certain aspects of teaching, as well as the value of a certain curriculum or instructional innovation (Guskey 2002). Programmes based on this idea are specifically designed to obtain teachers' and school officials' commitment, keenness, and validation before new practices can be implemented. Teachers may be included in the planning phase of such programmes, and surveys are conducted to determine teacher needs so that new practices are linked with what they require (Joyce, Mcnair, Diaz & Mckibbin 1976). However, as crucial as these techniques are, dramatic shifts in beliefs and attitudes are rare (Jones & Hayes 1980).

Lewin (1935), an early change theorist, took many of his ideas about influencing change from psychotherapy models and developed the above discussed perspective on teacher transformation. However, more recent evidence suggests that when it comes to professional development programmes for experienced teachers, this viewpoint on teacher change may be unrealistic (Huberman & Miles 1984; Guskey & Huberman 1995). As a result, an alternative model has been presented that leads to the construction of more successful professional development programmes and re-examines the process of teacher transformation (Guskey 2002).

2.7.1.1 An alternative model

Professional development programmes aim to achieve three key objectives: changes in teachers' classroom practices, changes in teachers' attitudes and beliefs, and changes in learners' learning outcomes. The order in which these outcomes occur is critical for enacting and facilitating the intended change, as well as its long-term sustainability (Guskey 2002). The alternative strategy to changing teachers' beliefs and practices is depicted in Figure 2.1 below. The three key results of the professional development programme are in a different order than the one stated in paragraph 2.7.1, as shown in Figure 2.1 below. According to the model, evidence of improved learner performance would lead to a major shift in teachers' beliefs and attitudes. This progress is due to modifications made by teachers in their classrooms, such as the adoption of new materials, revisions to teaching processes, or simply a fresh teaching approach.

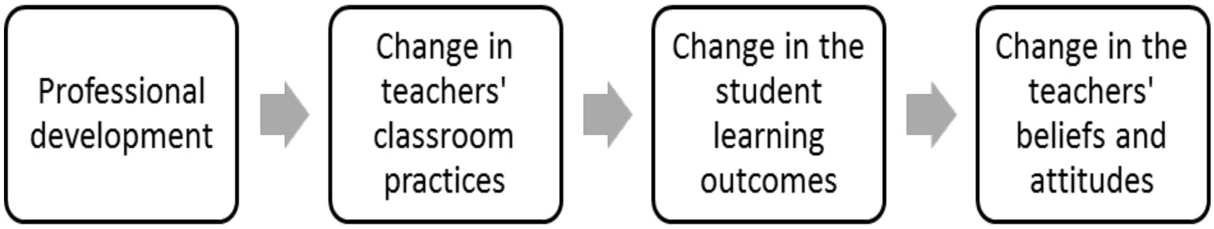


Figure 2-1: A model of teacher change (Guskey 2002).

a) Change in classroom practices

Guskey's model of predicted change assumes that change is basically generated from teachers' learning processes. Teacher techniques that do not result in considerable proof of success are halted at this level of the model, while those that are found to be effective in assisting learners in achieving their target performance are repeated and preserved. Improved learner performance is sufficient proof that any adjustment in teaching practice is beneficial (Guskey, 2002).

b) Change in teachers' attitudes and beliefs

It is undeniable that classroom experience has a significant impact on teachers' beliefs and attitudes about teaching. Teachers who have frequently failed to assist learners who lack access to educational opportunities to achieve exceptional learning, are prone to feel that these learners lack the ability to achieve academic excellence. Teachers' opinions may change if those learners achieve success in their learning because of new teaching practices developed by those teachers. This improvement in student performance is a prerequisite for most teachers' beliefs and attitudes to shift significantly (Guskey 2002).

c) Changes in student learning outcomes

The model's depiction of learning outcomes includes a wide range of learner attitudes and behaviour, not just accomplishment and cognitive components. Attendance, participation in class, classroom behaviour, motivation, attitudes toward school, quiz and examination scores, formal assessments, and achievement tests, the class and the learners themselves are all included. This means that learning outcomes relate to all other evidence that teachers use to assess the efficacy of their instruction (Guskey, 2002).

2.7.2 Support for the model

Teachers feel that new teaching concepts and principles are true "when they give birth to behaviours that work" (Bolster, 1983, p. 298). How these teachers feel demonstrates that new teaching strategies are difficult for experienced teachers to implement until they observe how well they work in their classrooms (Bolster 1983).

Crandall, Loucks-Horsley, Bauchner, Schmidt, Eiseman, Cox, Miles, Huberman, Taylor, Goldberg, Shive, Thompson, and Taylor (1982) investigated teachers' efforts to incorporate 61 creative teaching approaches in 146 districts across the USA. The growth of teachers' dedication to use the latest practices was most important to Crandall and his colleagues. Teachers' dedication to new teaching methods was frequently bolstered by project managers exposing teachers to problem-solving and decision-making before they could use them. However, this action by project managers had unfavourable consequences because new procedures were transformed beyond recognition by teachers, and their usefulness was lost as a result.

2.7.3 Implications for professional development

The following lessons can be learnt from this model of teacher transition:

2.7.3.1 Teacher change is gradual and a hard process

Learning to be an expert at anything new, and comprehending a new method of doing things, take both effort and time. It is unquestionable that every reform that has the potential to improve teachers' competencies and children learn, necessitates additional effort at the outset (Guskey 2002). Teachers are often cautious to accept new teaching approaches unless they are self-assured in their ability to implement them successfully (Lortie 1975).

Teachers run the risk of failing when they make a change or try something new. Not only will they be embarrassed if they fail, but it is also possible that others will oppose the move. Change entails the risk of learners learning more, or less effectively than they do at that time. This means that, even when exposed to evidence from meticulously planned experimental studies, teachers are hesitant to abandon or change the strategies they developed and refined in the their own classroom environments (Bolster 1983).

2.7.3.2 Provide teachers with continuous feedback

It is vital for teachers to receive regular feedback on the results of their efforts in order for them to keep using innovative strategies. It is undeniable that successful activities are motivating, and they are more likely to be repeated, while unsuccessful efforts are more likely to be abandoned. Similarly, if new and unfamiliar practices are seen to boost one's competence and success, they will be embraced and retained. This is especially true for teachers who take pride in their ability to positively affect their pupils' growth and development (Bredeson, Fruth, & Kasten 1983; Guskey 1989; Huberman 1992). Therefore, continuous feedback is essential towards successful professional development initiatives (Guskey 2002).

2.7.3.3 Provide continued follow-up, support, and pressure

According to the model, the desired change in teachers' attitudes and beliefs can only occur after implementation and proof of improved student learning. Ongoing follow-up, support, and pressure beyond the first training is therefore essential (Guskey 2002).

Continuous educational progress necessitates a balance of support and pressure. Support helps people to tolerate the risk of occasional failure during the difficult implementation phase, while pressure is typically required to commence change among those who lack self-motivation. It also provides an uplifting stimulant, and the odd nudge that many teachers need to keep going in the tough duties that all change initiatives entail (Airasian 1987; Huberman & Crandall 1983).

2.8 FACTORS AFFECTING TEACHERS' CHANGE IN BELIEFS AND PRACTICES REGARDING THE USE OF ICT

Teachers, according to research, are central to the effectiveness of ICT integration in learning and teaching. They can also be change advocates (Mathipa & Mukhari 2014). They are the ones determining the uptake of ICT in the classroom. At the same time, it is also important to note that the usage of ICT in the classroom is giving teachers new responsibilities (Eze & Olusola 2013). Teachers are no longer knowledge transmitters, but rather knowledge facilitators, who must motivate learners to build their own knowledge. They should engage learners in problem-solving activities, enhance their critical thinking abilities, instruct them on how to use the internet critically to find and select the information they need, and foster peer teaching, knowledge exchange, and social connection through collaborative work (Mathipa & Mukhari 2014). It is also worth noting that some ICT tools, such as overhead projectors, are becoming obsolete as teachers increasingly use a number of ICT resources to convey content in a variety of ways (Eze & Olusola 2013).

2.8.1 Age and teaching experience

More experienced teachers seem to be less likely to use computers than those with less experience (National Centre for Education Statistics 2013). The statistics for computer use in the classroom by teachers with 20 years or more experience was 33%. For those with 10 – 19 years of experience the figure was 47%, and for those with four to nine years of experience the figure was 45% (Afshari et al. 2009). Forty-eight percent of teachers with less than three years of experience reported using computers. The increased use of computers among teachers with three or less years of experience may be due to their exposure to computers during their training. As a result, they may have more experience with the tool than individuals with 20 years or more of teaching experience (Afshari et al. 2009).

Another explanation, according to Ruthven, Hennessy, and Deaney (2003), is that the younger generation is not scared of using new technologies than older teachers are. It is also possible that aging teachers are content with the traditional manner of teaching and believe that using technology has no advantage for them or their learners. They see no need to experiment with new inventive teaching methods (Mathipa & Mukhari 2014). Moreover, face-to-face and teacher-centred education approaches provide older teachers authoritative power in their classrooms (Makgato 2012).

2.8.2 Age and gender

Using the Theory of Planned Behaviour, Venkatesh and Morris (2000) examined age and gender disparities in individual sustained usage and adoption of technology in the workplace. Over a five-month period, 355 workers were researched to see how they used technology, and how they reacted to a new technology software. They discovered that the decision of men of various ages to adopt or not to adopt new technologies was heavily influenced by their attitudes. Women, on the other hand, were influenced more by perceived behavioural control and the subjective norm than by attitude when it comes to adopting new technology. This implies that distinct judgment processes for evaluating new technologies tended to be used by men and women of various ages in embracing new technologies (Venkatesh and Morris 2000).

2.8.3 Teacher qualifications

Teachers that are both educated and highly adept with technology, are able to overcome hurdles and be innovative, but they do not consistently incorporate technology as learning and teaching tools, unlike less educated teachers. Various factors contribute to this behaviour of highly educated teachers, such as the extra planning required for technology instruction and outmoded hardware (Bauer & Kenton 2005).

2.8.4 Teacher characteristics

One of the human traits that determines how teachers use computers in their classrooms is how they learn. A creative teacher who is a knowledge constructor, decision maker, social and life-long learner, will be more likely to integrate computers in transformative ways rather than ones that reinforce and reward normal learning practices (Bielaczyc & Collins 1999).

In his study on the dissemination of innovation, Rogers (1995) identified early and late technological adopters, based on their personal characteristics. Early adopters usually have a higher level of compassion, less hubris, a better-intentioned attitude toward change, a better capacity to deal with unpredictability and danger, less fatalism and higher goals, significant rationality, and a remarkable ability to deal with abstractions. Late adopters, unlike early adopters, are less ready to take excessive risks, are more practical in their judgments, have a firm grasp on difficulties, dislike infatuation, prefer to be directed by experience, and have a more authentic view of probability. As a result, early adopters will adopt technology more quickly than late adopters (Rogers 1995).

2.8.4.1 Teacher self-efficacy

Self-efficacy, according to Ormrod (2006), is the belief in one's own ability to attain the desired results. Self-efficacy has an impact on every aspect of human endeavour. Self-efficacy identifies an individual's ideas about his or her ability to influence events. Self-efficacy influences both the decisions a person is most likely to make and a person’s ability to tackle obstacles (Luszczynska & Schwarzer 2005).

Teacher self-efficacy influences the frequency and success with which teachers use technology (Sure 2009). Moore-Hayes (2011) postulates that teachers' opinions about their ability to work effectively with technology are directly related to the inclusion of technology in the classroom. Foreseeably, it was found that teachers who adopt, implement, and integrate ICT in their classrooms have more confidence in their competence (Sang, Valcke, Braak & Tondeur 2010). Teachers with high confidence are often looking for ways to enhance their teaching methods. As result, they are likely to be more receptive to new ideas and prepared to try new things in their classrooms. Unlike teachers with low computer self-efficacy, who are frustrated and hesitant to use computers when they run into problems, teachers with high self-efficacy are more likely to utilise computers because they have less computer-related anxiety (Sang et al. 2010).

Mueller, Wood, Willoughby, Ross and Specht (2008) noted:

> *"Although computer-related variables, in general, continue to impact on teachers' ability to integrate technology, it is positive experiences with computers in the classroom context that build teachers' belief in computer technology and confidence in its potential as an instructional tool" (p. 1533).*

Teachers' confidence grows when they see how technology helps learners to succeed, according to Ottenbreit-Leftwich (2007). Various suggestions for increasing teacher self-efficacy have been made in previous studies:

- More time is needed by teachers to use technology (Somekh 2008).
- Start small and build on your successes (Ottenbreit-Leftwich 2007).
- Collaborate with a knowledgeable colleague (Ertmer, Ottenbreit-Leftwich, & York 2006).
- Become a member of a professional learning community) (Putnam & Borko 2000).

- Professional development programmes (PDP) should be integrated into teachers' ongoing work (Cole, Simkins, & Penuel, 2002; Snoeyink & Ertmer 2002).

Since “innovation and adaptation are costly in terms of the time needed to develop and establish new practices”, adequate time is needed by teachers to make the desired changes (Hennessey, Ruthven, & Brindley 2005, p. 162).

2.8.5 School environment

The success or failure of ICT adoption and use can be ascribed to several factors, including school. Leadership and infrastructure are two external variables that affect the school (Jones 2004). According to Scrimshaw’s (2004) findings, in schools with hierarchical leadership, the principal makes decisions without consulting teachers. As a result, there is little desire to incorporate ICT into the classroom. With an inclusive leadership style, the principal makes decisions with the input of teachers, resulting in greater willingness and stronger morale to integrate ICT into the classroom (Scrimshaw 2004). According to Ottestad (2013), pedagogical usage of technology in schools is significantly linked to school leadership.

2.8.5.1 School leadership for ICT

In Norwegian schools, the use of ICT for instructional reasons is legislated by the national curriculum (NDET 2008). As a result, the Norwegian curriculum requires school leaders to promote the incorporation of ICT into instructional practice. School leadership for ICT is at the centre of ensuring that teachers incorporate and be creative with technology during teaching (Kirkland & Sutch 2009). It should also encourage digitally skilled learners by providing the necessary infrastructure and a supportive environment, and defined objectives and visions for the use of ICT in the classroom (Dexter 2008).

Principals' leadership is critical (Leithwood, Harris, & Hopkins 2008) in transforming schools from knowledge transfer institutions to learning institutions (Coppieters 2005). There are three types of school leadership: distributed (Leithwood & Mascall 2008; Robinson, Hohepa, & Lloyd 2009), pedagogical (Leithwood & Mascall 2008; Robinson et al. 2009), and transformative (Miller, Naidoo, Van Belle and Chigona 2006).

a) Distributed leadership

Interaction and activity between teachers and school leaders are emphasised in this style of leadership (Spillane 2005). In addition, both co-enactment and expanded boundaries between teachers and leaders are important in this form of leadership (Bennet 2008). When all team-based activities and role players are used in a systematic manner to focus on the learner and the learning process, strong communities of practice between leaders and teachers emerge (Miller et al. 2006). In comparison to schools characterised by an "island of innovations", where creative use of ICT is restricted to a smaller group, research findings revealed that when ICT is integrated school-wide, the school principal plays a critical role in launching innovations (Forkosh-Baruch, Nachmias, Mioduser, & Tubin 2005).

According to Dexter (2008), leadership decisions should be influenced and implemented by a broad team, which should include the principal, ICT coordinators, teacher leaders, and competent teachers. Teachers train their co-workers, question the traditional role of the teacher, and use their ICT competence to develop their pedagogical practice in schools where distributed leadership is practiced (Hatlevik, Tømte, Skaug & Ottestad 2011). At their schools, this type of teachers assumes the role of knowledge activists. When school leaders want to adopt creative ICT use across the board, knowledge activist teachers become particularly valuable, according to the distributed leadership perspective (Ottestad 2013).

b) Pedagogical leadership

Pedagogical leadership is a style of leadership in which school administrators participate in the pedagogical practice of teachers (Jackson & Marriott 2012). According to Dexter (2008), pedagogical leadership should be used to provide direction for ICT-based assessment and instructional practices. Pedagogical leadership further emphasises that the teachers' decision to participate in professional development that enhances the pedagogical use of ICT must be influenced by staff capabilities and needs (Dexter 2008).

c) Transformational leadership

When a leader fosters team learning, develops a common vision, and applies thinking processes, this type of leadership is called transformational leadership.

Transformational leadership is visionary and inspirational. The school principal is thrust into a prominent and charismatic role (Dexter 2008). The principal's role in transformational leadership is a blend of characteristics from all leadership approaches, characterised by functional delegation of leadership responsibilities to teams and individuals, clear delegation of formal roles and legitimacy, and close monitoring and counselling of teachers' needs and pedagogical practice. When ICT is used in everyday pedagogical practice, the school principals' role becomes even more important. Therefore, Stuart, Mills and Remus (2009) suggest that the school principal must take part in ICT-related professional development activities to take advantage of their new position as technological leaders.

2.8.5.2 School culture

Each group of teachers within a school or other institution, has its own set of norms that govern teaching techniques and behaviour. The norms of the school determine the type of aims and values to be promoted, as well as the appropriate resources or instruments to utilise, and also which instructional methods are favoured (Ertmer & Ottenbreit-Leftwich 2010). Somekh (2008 p. 450) have noted that "[t]eachers are not 'free agents' and their use of ICT for teaching and learning depends on the interlocking cultural, social, and organizational contexts in which they live and work" and regrettably, for most, the culture to which they must conform has not embraced a definition of powerful teaching that includes the notion of technology as an important tool for accelerating learner learning (Ertmer & Ottenbreit-Leftwich 2010).

When technology starts to diverge too much from the school's current values, beliefs, and practices (Zhao & Frank 2003), or if it "consistently destabilizes the established routines of classroom life, including norms of time and space" (Somekh, 2008, p. 452), or if it is "incompatible with the norms of a subject culture" (Hennessey et al., 2005, p. 161), it is less likely to succeed. Teachers who have been socialised differently regarding computer use by their peers, on the other hand, can more rapidly change their ideas about technology use (Zhao & Frank 2003).

Peer pressure and culture can have positive results (Ertmer & Ottenbreit-Leftwich 2010). Somekh (2008), for example, found that three schools from three different nations were able to help teachers accept technology in a pedagogically useful way.

According to Somekh (2008), school-wide innovation occurred when “the principal's vision and drive were of key importance” (p. 457), and the innovation resulted in “change like teacher–teacher interactions, based on collaboration and mutual support” (pp. 457–458).

2.8.5.3 School policy

The lack of ICT policy in most South African schools means that most schools do not have a clear strategy or training programme that can train teachers how to use computers during teaching (Gudmundsdottir 2010). The literature on technology integration provides abundant material on how this can be accomplished, but little information is provided regarding how the ICT policy of a school affects technology integration. Among the most important factors required for ICT integration in schools, according to Hew and Brush (2007), is a shared vision and ICT policy.

As defined by Fishman and Zhang (2003), Van Braak (2003) and Frazier and Bailey (2004), a school-based ICT policy includes both strategic and operational elements that integrate the use of ICT to enhance teaching and learning. They contend that a school-based ICT policy fits into a broader notion of ICT policy planning. It also provides a platform for examining how ICT can improve teaching and learning by providing a roadmap for the activities that a school intends to pursue (Fishman & Zhang 2003; Van Braak 2003; Frazier & Bailey 2004).

Their view is that a school-based ICT policy should reflect the aims, activities and expectations of the schools regarding ICT integration in education (Fishman & Zhang 2003; Van Braak 2003; Frazier & Bailey 2004). The development of staff, visioning, curriculum, assessments, and planning of ICT should all be incorporated into a school-based ICT policy (Van Braak 2003). It is also important to note that an ICT policy is not just about hardware and internet connectivity, but also about how ICT is incorporated into the instructional programme (Gülbahar 2007).

School ICT policy should be participatory, as indicated in the draft White Paper on E-Education published by the Department of Education (2004). It should involve a fair distribution of resources and a genuine commitment to teaching and learning. As an additional policy recommendation, the Department of Education (2004) calls for ensuring that all "end-users (learners, teachers, managers, and administrators)" have access to ICT on a regular and consistent basis. Successful ICT integration requires the development of a school-based ICT policy (Vanderlinde, Van Braak & Hermans 2009). Teachers utilise ICT more frequently in their classrooms in schools with a specific ICT policy, according to Tondeur, et al. (2008).

According to Vanderlinde, Van Braak, and Dexter (2012), ICT policy is composed of the following four policy domains:

- ICT policy in terms of vision development: connecting the school-based vision of ICT integration to the school's educational aims;
- ICT policy in terms of finances: ICT policy relating to infrastructure such as hardware and software;
- Professional advancement ICT policy: organisation and management of in-service ICT training courses for teachers in schools; and
- Curriculum ICT policy: implementation and management of ICT for learning and teaching.

Some scholars suggest that an ICT integration strategy would limit people's choice to choose the ICT training they want. It could also hamper the creativity of individual teachers, and that such a strategy may therefore be unnecessary. However, only a sound ICT strategy can meet the expectations of ICT in schools, which must be matched by the training to be supplied (Kwela 2013).

2.8.6 Teacher knowledge

In their first years of teaching, novice teachers have difficulty incorporating technology into their lesson plans due to their lack of understanding of the school context (Clausen 2007). Education officials have advocated the use of emerging technologies in teaching, but teachers reported feeling insufficiently prepared to teach using these techniques (Martin, Shaw & Daughenbaugh 2014). As a result, "...in order to assist teachers in changing their practice, they must be assisted in expanding and elaborating their knowledge systems" (Borko & Putnam 1995, p. 37).

2.9 EXPLORING PROGRAMMES INTENDED TO PROMOTE THE USE OF ICT

The findings from the investigation conducted by Law, Pelgrum, and Plomp (2008) revealed that just 15% of all ICT courses accessible to South African teachers include a curriculum on pedagogical concerns linked to how ICT might be integrated in learning and teaching. PanAf, as quoted by Ndlovu and Lawrence (2012), reports that ICT training in most South African public schools focuses primarily on fundamental computer skills, and this is insufficient to provide teachers with the skills they require to integrate ICT into their field of specialisation.

According to Howie and Blignaut (2009), most skills and information obtained by South African teachers are acquired through non-formal means such as teacher-to-teacher teaching, observation and informal contact, rather than via official routes. This implies that if technology is to be used for teaching and learning in South Africa, authorities must provide the training (Mofokeng & Mji 2010). Unfortunately, no one is certain about the type of ICT training that should be provided, so there is a lot of discussion and disagreement about how training should be conducted (Kwela 2013).

2.9.1 ICT training through blended learning

Technology uptake is affected by several factors, including teacher perspectives and attitudes toward technology use. These factors are the result of teachers' individual underlying personal ideas regarding the consequences of technology adoption (Sugar, Crawley & Fine 2004). Sugar, et al. (2004) argue that for technological adoption to take place, teachers must be prepared. Early research suggests that blended learning, whether face-to-face or online, can be effective, especially in programmes aimed at preparing teachers for technology adoption. Blended learning can enhance access, improve cost-effectiveness, and improve training (Qasem & Viswanathappa 2016), as well as give teachers more flexibility in incorporating technology into their classes (Khlaisang & Likhitdamrongkiat 2015).

Blended learning, whether face to face or online, is expected to help strengthen the integration of ICT into instructional design and teaching. Positive attitudes toward ICT integration and teacher performance can substantially increase since blended learning allows teachers to exchange ideas and fully participate in the learning environment (Qasem & Viswanathappa 2016).

Blended learning is a term that can be defined in a variety of ways. It identifies a combination of both physical and virtual worlds, according to the most popular definition (Bonk & Graham 2005). Graham, Allen and Ure (2003) identified three types of blended learning systems:

- Enablement of blending: Different learning modes are used for the learners, but they share the same learning experience. Learners can select the method that best fits their budget and schedule.

- Enhancement of blending: Learning is mainly conducted in a face-to-face manner. The type of learning management system adopted is the one that provides supportive resources for courses.

- Transformation of blending: As the primary method of instruction, traditional learning is integrated with technology-mediated approaches.

The adoption of a blended learning approach has raised significant arguments in the literature, while at the same time its use is described in a large volume of literature. In contrast, there are few empirical studies on it in programmes for teacher education (Ho, Nakamoria, Ho, and Ho 2013; Keengwe & Kang, 2012; Abidoye 2015). To analyse the impact of blended learning, Nazarenko (2014) interviewed students who had completed a blended course. He discovered that these students were enthusiastic about learning in a hybrid environment. A positive attitude is the outcome of the ability to learn from others by obtaining their opinions, recommendations, or reactions, as well as giving or receiving assistance from moderators (Weaver 2005).

In a study by Geçer and Dağ (2012), students' perceptions on computer courses presented and implemented in a hybrid learning environment were studied. The findings revealed that the use of technological activities in the training had a positive influence on students, both in terms of evaluation and learning. Students also noted that the blended learning environment and online projects impacted their active engagement in academic activities, and that homework was entertaining and valuable.

El-Deghaidy and Nouby (2008) and Plešec Gasparič and Pečar (2016) also discovered that students who enrolled in blended learning courses had more positive feelings about e-learning than those who enrolled in face-to-face courses. Eryilmaz (2015) therefore believes that educational practices created inside blended environments are highly helpful in terms of learning, attention, motivation, contentment, teacher performance in ICT integration, and the development of positive perceptions about e-courses.

2.9.2 ICT training through the Khanya Project

The Western Cape Education Department initiated the Khanya project in May 2001, with the goal of completing it by March 2012 (Du Toit 2004). The goal of the project was to solve the developing crisis in the usage of ICT in South African education. Khanya comes from the Xhosa verb "ukhukhanya," which means "to illuminate or enlighten" (Rahimi, Beer & Sewchuran 2012).

The intention of the project was to increase teachers' ability to integrate the use of affordable, readily available, and appropriate technology into the curriculum. This programme was designed to help under-resourced schools in Western Cape districts. The facilitators were crucial to the success of the project because they were tasked with assisting teachers to integrate ICT into their daily classroom practices (Rahimi et al. 2012).

The facilitators in this project were all ex-teachers with ICT experience, experience in working with "previously disadvantaged" students, and they all had at least ten years' experience as teachers. Face-to-face and hands-on ICT skills training was provided to teachers with specific curriculum targets in mind. The type of training to be conducted at a particular school was determined by the teacher's prior learning levels in that school (Du Toit 2005).

A brief trial to train teachers on how to use e-learning resources was conducted at the start of the programme, but it was abandoned. Most of the teachers who took part in this training had never seen or used a computer before. The non-use of computers by teachers sometimes resulted in them taking longer to master the essential skills needed to use technology in their daily teaching practice, and they also seemed to experience a sense of threat from new technology. A trusting relationship with the facilitator is often necessary to shift teachers' attitudes and overcome their ingrained anxiety (Du Toit 2005).

Parallel to ICT skills training, training on the principles and practice of integrating ICT into normal teaching practice should be initiated. Appropriate instructional software should be introduced progressively. It is important to note that curriculum implementation does not drive the utilisation of computer laboratories, but the opposite is true. Teachers can resume regular classes in the computer lab once formal training has been completed, and they feel confident to use computers. Teachers should also be offered ongoing technical and software support, as well as demo lessons that empower them (Du Toit 2005).

The "e-school project plan" in the Khanya initiative was created by the e-school project manager at the outset of the support phase. It lays out the entire facilitation process, as well as the corresponding curriculum outcomes, complete with project timelines. Once all the outcomes have been met adequately, the school will be considered "independent," and visits will become less frequent. Even when the school has become self-sufficient, the teachers or school can contact the facilitator at any time if they have problems or require assistance. Due to its unique methodology, the Khanya initiative has garnered two renowned prizes recognizing its accomplishments (Du Toit 2005).

Du Toit (2005) reported on the Khanya Project's planned aims, programme layout, and successes, while Rahimi et al. (2012) revealed that the Khanya project had not achieved its intended goal by 2012. During the implementation, difficulties were discovered. Thematic analysis found that the divide between resource receivers and suppliers was ever-increasing. According to one teacher, "they, Khanya, specify who can use it and who cannot, as well as when it can be utilized and when it cannot. The Khanya laws are too rigid; there is no room for error, and if they say mathematics people can use it, then only mathematics people can use it". “The red tape around the utilization of the laboratories prohibited teachers from getting into the laboratories for the hours that they needed to get comfortable with the technology”, another teacher said (Rahimi et al. 2012).

It seems as if the Khanya project was prone to micromanagement, as seen in the quotes above. There were also signs that teachers were rejecting the use of technology.

"We have a staff component that is made up of an elderly group on the one hand, and a younger group on the other," teachers explained. The younger generation immediately adopted computers, while the older generation was hesitant and needed persuasion. Senior management had to show the older teachers that technology can help them to learn more effectively. "When you think of using the computer for teaching, you have to think twice," another teacher continued, "since the youngsters these days tend to know more about computers than we adults do" (Rahimi et al. 2012).

Because the older educators were unable to adapt to the technology, they were opposed to it and worried about the impact it would have on their careers. Not only were the older teachers unprepared, but Khanya also insisted that specific subjects be prioritised. Teachers whose disciplines were not prioritised felt as if their professional growth was not valued. The thematic analysis of the project revealed that the relationships between teachers in the school were not conducive for teachers to become empowered to use the computer lab. According to the findings, Khanya was to be blamed for the unstable environment in the schools (Rahimi et al. 2012).

There was no mention of a support committee at the school during the interviews, implying that teacher support was informal. In the corridors or whenever teachers spotted one another, teachers would seek for help. "There's a lot of selfishness among themselves," teachers said, "thus sharing knowledge among teachers who used the computer lab had its issues." For example, some teachers were Excel specialists, but could not share their skills with other teachers, implying that true teacher empowerment did not exist (Rahimi et al. 2012).

The thematic analysis of the project pointed to nine obstacles negatively impacting technology integration, in addition to the disapproval and negative remarks by the teachers. These were noted by a member of the Khanya project (Rahimi et al. 2012) as follows:

- a lack of assistance from the department;
- a lack of support and guidance from the principal;
- a scarcity of educational opportunities;

- no time set aside to develop the skills;
- overburdened by a plethora of administrative responsibilities;
- having to attend far too many curriculum-related training sessions;
- faulty technology;
- insufficient (or non-existent) technical assistance, and
- a scarcity of time slots in the computer room.

It is worth noting that only one of Khanya's nine major difficulties was related to technology or infrastructure. This could be proof that such programmes should be led by well-defined policies. Conditions should be established that not only allow for the effective use of e-learning technology, but also allow for social elements that will allow for smooth adoption and rollout without imposing a dominant culture or producing tension within schools. Rahimi et al. (2012) recommended that the initiatives should allow schools to be more active and to be consult in the process, as well as have more decision-making power, in addition to offering ICT-centred training.

2.9.3 The Intel® Innovation in Education Teach to the Future ICT programme

Intel® Teach to the Future is a global initiative focused on assisting teachers in incorporating technology into their classrooms to help learners learn more effectively. It was first released in the United States in 2000. The USA is a well-resourced, technologically sophisticated country with teachers who appear to be competent. The programme is presently in use in 33 countries throughout the world. It stands out for its focus on dedication, as exemplified by Intel® President Dr Craig Barrett's remark that "computers aren't magic, teachers are," and pedagogy (Barrett 2000).

The programme was initiated in South Africa in 2003. The South African Council for Educators (SACE) endorsed the programme, which was backed by the National Department of Education and aligned to the South African National Curriculum

Statements (Wilson-Strydom & Thomson 2005). The intended goal of the Intel® Teach to the Future programme in South Africa is stated as follows:

> *"To train classroom teachers how to promote project-based learning and effectively integrate the use of computers into Curriculum 2005 and Revised National Curriculum Statements so that learners will increase their learning achievement" (Intel® Teach to the Future Training Manual, 3.3, p.1).*

The curriculum emphasises the use of teachers' own instructional units in which they work on all areas of a project of their choosing, including assessment and the creation of a rubric library, as well as hands-on learning. Furthermore, throughout the programme, teachers solve problems, participate in peer reviews, and work in groups. This is done to fulfil the desired goal of exploring various methods in which teachers might effectively employ technology to heighten learning. As a result, teachers with varying levels of computer knowledge, as well as advanced teachers, can use the application to optimise cross-curricular planning opportunities (Wilson-Strydom & Thomson 2005).

The programme uses a project-based learning approach, with ten modules of at least four hours each focusing on assisting teachers in efficiently integrating ICT into the curriculum. As much as there is a pressing need to transform teachers, it is undeniable that many lack expertise, especially in the project-based learning that the Intel® Teach to the Future presupposes, and that most teachers are unskilled or untrained (Crouch & Perry 2003). Teachers were not only unfamiliar with project-based learning, but also with learner-centred methodology and ICT, and the programme's success was hampered by a lack of fundamental infrastructure (Herselman 2003).

A thousand schools across all the nine provinces in South Africa were involved. The school nominated teachers to participate in the programme, then the provincial senior trainers would train the nominated teachers. From the provincial one-week training, the teachers would then train their colleagues at their respective schools. For newly trained teachers, an additional requirement would be placed on them. The provincial department officials in various Provincial Departments of Education would undergo national training. They would be expected to train teachers when Intel® no longer funds the teacher training. This method of implementation is known as the "Train the Trainer" model (Wilson-Strydom & Thomson 2008). In "Train the Trainer" approach, it is expected of newly trained teachers to be able to pass on their newly acquired abilities before they have reached sufficient levels of knowledge and confidence, making it easy for them to fail (Roos 2002, p25). Since not all learning areas are accommodated, teachers in this approach struggle to adapt abilities learned in general training to a variety of learning areas. Mbatha (2015) refers to this strategy as a one-size-fits-all approach.

This approach has proven integrity in certain countries (Sherry, Billig, Tavalin & Gibson 2002), but has a bad reputation in South Africa because of questionable methodology and insufficient content during the early stages of training for the new national curriculum (Chisholm 2000).

Because of the insufficient number of experienced teachers and too few competent facilitators, the Intel® Teach to the Future programme resulted in random failures and successes. In evaluating the programme, the following findings were found:

- Poor facilities and teachers' lack of confidence in their technical and pedagogical skills were the two most significant factors that contributed to trained facilitators failing to provide training in their schools (Wilson-Strydom 2004);
- Limited numbers of computers resulted in teachers having reservations to implement the learner-centred approach despite them having creative ideas about it (Wilson-Strydom 2004);
- Teachers who participated in the Intel® Teach to the Future initiative were mostly those who lacked the necessary ICT skills (Wilson-Strydom 2004); and
- “Teachers require more support to find innovative ways of using scarce ICT resources” (Wilson-Strydom 2004, p. 9).

The scarcity of qualified candidates, especially at provincial level, raised concerns regarding quality assurance, such as how learning can become better “when teachers lack the required ICT skills and tend to focus on the ICT aspects of the training to get through rather than the important pedagogical aspects”? (Wilson-Strydom 2004, p. 4). Many individual teachers, both from underprivileged and from wealthy, well-resourced schools, expressed an apprehension about inquiry-based learning. For an example, "according to the facilitator, teachers want to learn about computers rather than complete curricular work at the start of the training. This is one of the reasons why teachers struggled to grasp the principles of various types of inquiries. The facilitator also mentioned that explaining topics to teachers is difficult" (Wilson-Strydom 2005, p. 41).

2.9.4 New Opportunities Fund ICT training

The Department of Education responsible for Northern Ireland's education technology plan summarised it as follows:

> *"… the effective use of information and communications technology (ICT) in the classroom can measurably enhance the learning environment and enrich the educational experience of all our young people. Well used, education technology can encourage a more participative and independent approach to learning, thereby laying the foundations for lifelong learning and personal development" (DENI 1997, p. 6).*

By the year 2003, the strategy expected all teachers to be proficient in the use of ICT in their classrooms. The New Opportunities Fund training is one of the initiative's measures. New Opportunities Fund training was implemented between 1998 and 2003 with the goal of raising the standard of learner accomplishment in the schools in the United Kingdom by enhancing the technological knowledge of serving teachers. As a result, Northern Ireland's educators were expected to:

- understand which technology-based resources are accessible in their disciplines and how to use them with individuals, groups, and full classes.
- Continue their professional development to stay current with new methods, resources, and advancements, as well as to evaluate their students' learning in an ICT setting (DENI 1997).

The Office for Standards in Education (OFSTED) published reports in 2001 and 2002 on the impact of government ICT programmes in schools, and various difficulties related to the training were highlighted. The training did not consider teachers' various ICT backgrounds, and schools were unaware of the type of training they would receive despite having already committed to it. A fundamental issue in the training programme was the inability to focus on teachers' area of specialisation, and this was considered as a serious flaw. There was also a shortage of time for teachers to follow up and complete the training. Where successful, however, there was a general increase in how often technology was used to teach certain topics, particularly in secondary schools, as well as teachers' trust in using technology to teach. However, it should be mentioned that the success of NOF training was determined by the condition in which it was implemented at the school, not by the standard of the training offered. “Much of the NOF ICT training is not on track to accomplish its potential,” the report concluded (OFSTED, p. 21, 2001).

According to OFSTED (2002), the NOF training was successful in a third of primary schools and a quarter of secondary schools in 2003. In around 50% of primary and 60% of secondary schools, the training failed to effectively prepare teachers to address pedagogical challenges or to develop teachers' ICT skills. In a limited number of schools, the training boosted progress. The following are the characteristics of a successful NOF training programme:

- ICT is identified as a school priority,
- staff members are already proficient in using ICT,
- senior managers take active interest in teachers’ training,
- teachers are given the opportunity to select and adapt the NOF training materials that met their needs, rather than dutifully working through them,
- teachers have access to a personal computer, particularly at home,
- teamwork and peer support are the norm.

Schools that failed to complete NOF training did so because of the non-availability of a competent post-NOF staff development programme. The following are some of the issues raised by educators who were unable to finish the training:

- insufficient time,
- organisational and technical difficulties,
- lack of assistance from mentors or trainers,
- training materials poorly matched to teachers’ needs,
- portfolio compilation and exercise completion requirements were unrelated to current work environment.

Teachers frequently complained about mentors' failure to respond to messages, trainers' underestimation or exaggeration of teachers' prior knowledge, and the inability of trainers to establish a productive working connection with teachers. The training programme was unable to fulfil the needs of teachers who lacked confidence, as well those of as highly skilled ICT users. This implies that there was no distinction between users. Some students left to their own devices to use CD-ROM-based distance learning tools made little progress and did not finish the programme. Finally, expected to work on training materials outside of school hours placed significant strain on teachers' time (OFSTED 2002).

2.9.5 Summary lessons learned from the example ICT programmes

For models of teacher development in ICT to be successful, various challenges must be addressed. These include adequate resources and equipment, good social and technical support, and adequate time. Teachers should be involved in the design of the content of the programme for it to be suitable to their teaching approaches, and school administration teams should actively support and be committed to the goals of the professional development opportunities. A flexible delivery approach must be used to reflect the teachers' levels of ICT expertise as well as individual demands. Tutors or the programme must recognise the audience's various learning styles as well as the problem of teachers' attitudes toward ICT. Also, the willingness to change teachers' attitudes and perceptions about the use of ICT is important (Galanouli, Murphy & Gardner 2004; Qasem & Viswanathappa 2016).

Successful ICT training models, according to Davis, Preston and Sahin (2009), should prepare teachers and provide them with assistance (Steyn & Van Greunen 2014), and be done in the same way that teachers are expected to incorporate ICT (Davis et al. 2009). Sang et al. (2010) state that constructivist teacher training should be used because it will provide teachers with a non-threatening environment in which they can acquire confidence and experience success with computers. Teo (2009) and Holland (cited in Law, 2008, p. 427) agree that "teacher training should prepare teachers not only for any kind of ICT integration but should equip teachers for the best practices in ICT integration that contribute to improving existing teaching practice to achieve the goals of school reform".

2.10 ASPECTS TO CONSIDER FOR ICT TRAINING PROGRAMME TO HAVE A BETTER CHANCE TO CHANGE TEACHER BELIEFS AND PRACTICES REGARDING THE USE OF ICT

According to Kwela (2013), when conducting technology training, several factors must be considered to achieve improved ICT integration. Teachers' ICT expertise, the need for support following ICT training, the duration of the ICT training, and the ICT training model are all factors to consider.

2.10.1 Teachers' level of ICT competency

It is undeniable that teachers have varying levels of ICT competence. Consequently, the ICT programme provided must be relevant for the teachers' competence levels regarding the use of technology (Kwela 2013). ICT skills are defined by Lawrence and Veena (2012) as a set of technology criteria that describes excellence in how technology is used in the classroom. These abilities are divided into four categories of computer-related abilities: (1) personal and professional use of technology tools, (2) basic technology operation, (3) technology in instruction, and (4) issues of social, ethical, and human nature.

Various models, such as the Western Cape Provincial Government Gazette Model (2004), the World Programme Profile Model (2001), Model for ICT curriculum and teacher development in schools (UNESCO 2002), Rieber and Welliver's (1989) Transformation model, and Clarkson and Oliver's (2002) model, all describe levels of ICT competences in various ways:

a) ICT competencies are classified into five levels in the Western Cape Provincial Government Gazette Model (2004):

- **Level of entry:** At this level, teachers can teach learners to use computers and can use computers themselves. They are referred to as computer literate;
- **Level of adoption**: Teachers can employ numerous technologies, such as computers, to support learning and teaching, traditional management, and administration at this level;

- **Level of adaptation**: At this level teachers use integrated systems for administration and management, and technology is used to enrich the curriculum;
- **Level of appropriation**: At this level teachers can integrate ICT into learning and teaching activities, and
- **Level of innovation**: At this level teachers can develop entirely new learning environments where technology can be used as a flexible tool.

b) The World Programme Profile Model (2001) includes 0 – 4 phases, namely***:***

- **Phase Zero**: At this phase, the fundamentals of computer technology are introduced, and participants are assisted to acquire basic computer literacy;
- **Phase One:** The audience has been introduced to the internet for learning and teaching;
- **Phase: Two**. The audience is introduced to tele collaborative learning projects;
- **Phase Three**: At this phase, technology integration into learning and teaching occurs, and
- **Phase Four:** This phase focuses on developing the knowledge of how to spread and assess innovative teaching techniques while also addressing social and ethical problems.

c) According to the Model for ICT curriculum and teacher development in schools (UNESCO 2002), there are four stages to ICT integration:

- **Stage of emerging:** This is the first stage where ICT is added into curriculum and teachers and administrators begin to investigate the consequences and possibilities of the use of technology for the management of the school;
- **Stage of application:** This is the second phase, during which teachers and administrators can use ICT to complete duties that are already part of the curriculum and school management.
- **Stage of infusion:** At this stage new ways in which ICT changes teachers' professional practice and productivity are explored, and
- **Stage of transformation**: At this stage, ICT is incorporated into all vocational areas and can be taught as a separate subject.

d) Key properties of the levels are described as follows in Rieber and Welliver's (1989) Transformation model:

- **Familiarisation:** A teacher encounters technology for the first time at this level. The emphasis is on the utilization of technology-related software and hardware.

- **Utilisation:** This is the initial step in a teacher's application of newly acquired technological abilities to some of his or her teaching methods, such as utilising word processing to send information to parents, producing tutorials, and keeping a computerised grade book up to date.
- **Integration:** The teacher is aware of the results that technology has on learning. As a result, the teacher promotes project-based activities that require students to do assignments using the internet. The teacher further directs the activity by mentioning websites and resources that the students may find useful.
- **Reorientation**: At this level, teachers assist students in identifying and achieving their objectives. They may advance from developing and delivering lessons to planning them together with students, and
- **Evolution**: At this level, teachers can find solutions in diverse and unlikely places and have the capacity to transform technology. New ways of using technology are investigated, and there is collaboration with other teachers beyond their district or school.

e) Clarkson and Oliver (2002) identify four phases towards integrating ICT in their classrooms. These phases are dependence, counter-dependence, independence, and interdependence:

- Dependence phase: Teachers in this phase have very little prior experience with ICT. As a result, they may focus more on the development of their technical abilities than on the application of pedagogical knowledge regarding ICT integration.

- Counter-dependence: Teachers with the confidence to utilise ICT in their personal lives and, to a limited extent, in their classrooms, are in this phase. As a result, they should be able to devote some of their time to the growth of their TPACK, but this will most likely be done under the supervision of another teacher.

- Independence and interdependence: Teachers who are already integrating ICT in their lessons can be in either of these phases. It may be reasonable to expect such teachers to use ICT in increasingly learner-directed manners.

Various models discussed above propose that before ICT training can be conducted, teachers' ICT baseline should be assessed to determine their competence level in ICT. Another main point is that in order to transform teachers' initial skills into the highest possible level, training must fit into teachers' ICT competency level (Kwela 2013).

2.10.2 The need for support after training

School Net SA, Mindset, and Intel®'s "Teach to the Future" are all ICT teacher training programmes aimed at expanding resources for educational technology (Department of Education 2004). Even though the ICT programs discussed in paragraphs 2.9.1 - 2.9.4 have many great visions, one problem was that they don't have a teacher follow-up assistance programme. The Intel® Teach 2008 Evaluation Report indicated that the effectiveness of the Intel® Teach to the Future programme was limited due to a lack of basic IT competency screening and post-training support (Roberts, Mmekoa & Mawoyo 2009). According to Atkins and Vasu (2000), Bradshaw (2002) and Feist (2003), teachers who are trained and who attend follow-up sessions are more likely to use technology in their classes. A process of post-training follow-up is therefore critical.

2.10.3 Duration of the training

According to research on ICT teacher training conducted in the 1990s, there is no consensus on the appropriate period for teacher training (Hawkins & MacMillan 1993; Kinnaman 1990; Shelton & Jones 1996; Harvey & Purnell 1995). As a result, there are no clear recommendations on the duration of an ICT teacher training programme. However, recent findings by Davidson, Fields, and Yang (2009) suggested that ICT training programs with at least 14 hours of interaction have favourable and notable benefits on learner accomplishment.

2.10.4 ICT training model

There are different perspectives on the goal of technology teacher training. For example, Guzman and Nussbaum (2009) believe that the focus of technology integration should be to improve learning and teaching, rather than to increase technological knowledge. Technology training, according to Earle (2002) (also see Ertmer, Conklin, Lewandowski, Osika, Selo & Wignall 2003), should emphasise the technological or instrumental components. Teachers expressed concerns in a study by ChanLin, Hong, Horng, Chang, and Chu (2006) that ICT programmes did not give them the essential ICT abilities to attain high-quality professional performance concerning ICT integration. ICT training programmes that are unable to provide the required guidance to ensure that teachers fully address the true challenges of the profession, according to Smith and Robinson (2003), are frequently not true professional development projects.

As a result, there is a set of professional competences that professional development training should adhere to so that improved technology integration can take place (Guzman & Nussbaum 2009). Instrumental or technological, pedagogical or curricular, methodological, evaluative or investigative, communicational or relational, and personal or attitudinal are the six main domains of activity. Any technology training approach should include these domains and associated competencies for improved technology integration.

2.10.4.1 The instrumental or technological domain

This domain is emphasised as important by several writers because the basis for the work to be done is formed in this domain. In this domain, it is emphasised that teachers need to acquire technology-handling abilities. After acquiring these abilities, teachers can use both specific software and hardware in an instructional context. Improved technical abilities lead to significant teacher confidence, which is required to integrate technology (Markauskaite 2007). When teachers successfully use technical equipment in their subjects, their level of confidence in using technology grows, as does the likelihood of improved learner achievement (Albion 2003). According to Demetriadis, Barbas, Molohides, Palaigeorgiou, Psillos and Vlahavas (2002), teachers are unlikely to be able to incorporate technology into their classroom instruction, and the pedagogical success of doing so is even less likely if they lack essential computer abilities.

2.10.4.2 The pedagogical or curricular domain

The inclusion of curricular factors in the ICT teacher training process is important (Guzman & Nussbaum 2009). Cox, Abbott, Webb, Blakeley, Beauchamp, and Rhodes (2004) believe that without teachers gaining the necessary pedagogical abilities, it will be impossible to arrange actions that promote educational reform, or to undertake technology initiatives that will bring creative scenarios to schools. According to Okojie, Olinzock, and Okojie-Boulder (2006) and Hew and Brush (2007), a strong knowledge of the pedagogical ideas that support teachers' actions is a constituent factor in technology integration. This knowledge will help to improve learning and teaching.

Even though there are specific basic technical skills that teachers must have, the use of technology in teaching and learning will not happen until, as (Zhao, Pugh, Sheldon & Byers 2002 p. 492) puts it, "teachers viewed technology as the means to an end, rather than an end itself, and when they saw an intimate connection between technology and the curriculum". This suggest that the use of technology should be part and parcel of teacher training towards "establishing a close connection between the curriculum and technology" (Kwela 2013 p. 24).

2.10.4.3 Methodological domain

The other component of the teacher ICT training programme is the methodological factor (Kwela 2013). This is the growth of instructive knowledge that enables the incorporation of technology into classroom-based teaching and learning activities. This then implies that instruments that aid teachers in the creation of learning environments coupled with solid, genuine encounters, must be supplied if technology integration is to take place (Li 2005).

2.10.4.4 The evaluative or investigative domain.

The feedback generated between how technology deployment is proceeding, and the student learning process, is referred to as the evaluative or investigative domain. In either instance, the obtained evidence should be used to make quick and efficient decisions (Kwela 2013). The identification of issues and the construction of feasible solutions can both be accomplished through evaluative research. As a result, this domain could be used to determine the extent to which teacher ICT training is meeting the initial aims, as well as the presentation of evidence for accepting and implementing related solutions as needed (Mills & Tincher 2003).

2.10.4.5 The communication or relational domain

This is a critical component that must be incorporated in ICT training, because educational interaction between learners, or between learners and teachers, takes place in a completely different context in a technological environment. Technology is employed in this context for synergetic work, which necessitates significant capabilities to establish procedures for achieving consensus. Collaboration is crucial if the focus is on the mediational process managed by the classroom teacher, whose communication skills are fundamental to facilitating good learner accompaniment and interaction (Mills & Tincher 2003).

Insufficient communication, according to Tweddell Levinsen (2007), restricts the efficiency of engagement, resulting in a low-quality learning environment. Communication barriers are difficult to overcome, while technological barriers are easier to overcome. This implies that, for successful engagement to occur, teachers' beliefs must be profoundly altered (Tweddell Levinsen 2007).

2.10.4.6 The personal or attitudinal domain

Guzman and Nussbaum (2009) believe that the personal element must be included for technology integration to be adopted in the classroom. They say that the subjectiveness of the teacher in charge of the progress determines how technological design is interpreted and implemented, and that the attitudinal aspect is what at the end determines the standard of performance. In the end, concrete instructional methods are influenced by the personal component, which shapes teacher representation.

Markauskaite (2007), for example, claims that the ways in which people interpret, project, and see technology influence how they use it. The expectations, experiences, emotions, and beliefs of teachers are amongst the personal elements that influence technology incorporation in the classroom, and they must be explicitly acknowledged in teacher training (Wood, Mueller, Willoughby, Specht, & Deyoung 2005; ChanLin et al. 2006).

2.10.4.7 Summary of the ICT training model

The areas that are linked to a set of general teaching competencies that define technology teacher training are defined in paragraphs 2.10.4.1 to 2.10.4.6. Outcomes-Based Education (OBE) has long advocated for a competency-based approach to teaching and learning, which may have influenced how teachers integrate technology into their classrooms (Kwela 2013). "Such a competence-based approach, if well-founded, would provide goals for training, but would give no insight into the processes by which learning occurs," arguing that "the focus is still on the destination rather than the journey to be walked" (Taylor 2004, p. 43). As a result, it is vital for teachers to be transformed by understanding the processes involved.

"In a transformed teaching and learning environment, there is an inclusive and integrated practice where learners work collaboratively, create shared practices, engage in relevant contexts, and develop creative thinking and problem-solving skills," the Draft White Paper on e-Education concluded (Department of Basic Education 2004, p.16).

Table 2-1: Synopsis of the findings of the literature review on the lessons that can be learned

Issues	Literature suggests	Section
Teacher ICT beliefs and their impact on pedagogy	Teachers who are positive about ICT are more likely to use technology to meet their educational needs.	2.3
	Teachers with negative ICT beliefs are less likely to adopt ICT.	2.3
	When teachers are successful when they use technology, they are more likely to adopt it.	2.3
	The more successful teachers are in using technology, the more they expose themselves to various ICT applications.	2.3
Relationship between teachers' pedagogical beliefs and ICT usage	Pedagogical beliefs drive how technology can be used and not the other way round.	2.4
	Teacher contexts influence how technology can be used (learner-centred or teacher-centred).	2.4
	Teacher contexts are influenced by individual teacher experiences, emotions and motivation.	2.4
Relationship between beliefs and practices	Teachers' attitudes toward teaching and learning are reflected in how they employ technology in the classroom.	2.5
How and when can beliefs change	Belief change is conceptualised as an aspect of continuous professional development for pre-service and in-service teachers regardless of the duration of the programme.	2.6
	Belief change is reported to be more likely to occur in strategy-focused programmes.	2.6

	The extent of belief change is conditioned to factors such as target beliefs, as well as individual and contextual factors.	2.6
Predicting teacher changes in beliefs and practices through professional development	Professional development must have goals.	2.7.1.1
	To effect change in teacher beliefs, a sequence of training goals is important.	2.7.1.1
	There must first be evidence of positive learning outcomes for a significant change in teachers' beliefs to occur.	2.7.1.1
	Teachers make improvements in their classroom methods that result in positive changes in learning outcomes.	2.7.1.1
Factors affecting teachers' change in beliefs and practices regarding the use of ICT	*Age and teaching experience*	2.8.1 (RQ3)
	Age and gender	2.8.2 (RQ3)
	Qualifications	2.8.3 (RQ3)
	Teacher characteristics	2.8.4. (RQ3)
	Creative thinking and long-life learning	2.8.4. (RQ3)
	Self-efficacy	2.8.4.1
	School environment	2.8.5
	Infrastructure	2.8.5.
	School leadership	2.8.5.1
	School culture	2.8.5.2
	School policy	2.8.5.3
	Teacher knowledge and skills	2.8.6 &
	Lack of support and confidence	1.1
Exploring programmes intended to promote the use of ICT Factors with a negative effect	There is a lack of training on pedagogical issues about how ICT can be integrated in South African schools.	2.9
	Khanya Project: Lack of support and guidance to teachers by principals.	2.9.2
	Lack of technical support.	2.9.2
	Poor infrastructure.	2.9.2

	Intel® innovation in education project: limited number of computers.	2.9.3.1
	Expecting only basic ICT skills training rather than pedagogical ICT training.	2.9.3.1
	New Opportunities Fund ICT Training: lack of differentiation between different levels of experience with ICT.	2.9.4
Aspects to consider in a training programme intended to change teacher beliefs and practices	The level of ICT competency of teachers.	2.10
	The type of ICT training model.	2.10.4
	Technological domain.	2.10.4.1
	Pedagogical domain.	2.10.4.2
	Attitudinal domain.	2.10.4.6

2.11 CONCLUSION

Teachers' beliefs about how learning and teaching should take place are a crucial aspect in determining how ICT is used in the classroom (Orlando 2009; Wozney, Venkatesh, & Abrami 2006). Keys (2007) believes that educational beliefs are created over several years of teacher experience, ranging from student life in the classroom to the range of professional contexts he or she is faced with. As a result, it appears that changing teachers' beliefs is difficult. Beliefs have usually been in existence for a very long time, and according to Albion and Ertmer (2002 p. 35) "are supported by strong authority and broad consensus". Prestridge (2012), on the other hand, contends that just because beliefs are difficult to alter does not mean that they cannot be changed. In the context of teacher change, authors such as Prestridge (2012) and Shriner, Schlee, Hamil, and Libler (2009) argue that effective professional development should encourage instructors to question and modify their pre-existing educational views.

As much as teacher beliefs are critical factors in how ICT can be integrated into the classroom, factors such as age, gender, qualifications, teacher characteristics, teachers' self-efficacy, and the school environment cannot be ignored. This suggests that ICT training programme developers should not overlook these factors, as they can influence the uptake of ICT positively or negatively.

There are programmes that can change teachers' views and practices about the use of ICT, and programmes that cannot affect teachers' beliefs and practices about the use of ICT.

For any ICT training programme to successfully achieve its intended objectives, factors such as teacher ICT competencies, the need for post-training support, and the different types of domains to be covered in the ICT training should all be taken into account when planning such a programme. The theoretical frameworks that guided the study, the ICT model used to identify the ICT competency level of teachers in this study, and the ICT framework used to evaluate the final assessment tasks of teachers in this study will all be discussed in the following chapter.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 INTRODUCTION

Technology develops at an alarming rate, in particular information and communication technology, and how people integrate it into their professional and private lives. However, teachers' decisions to reject or accept technology for educational purposes remains of concern. Studies on technology acceptance and its associated factors in the area of Information System and end-user computing have increased over the years (Gu, Zhu & Guo 2013). During the previous few decades, the research community has generated several frameworks, models, and theories of effective technology use and acceptability (Marangunić & Granić 2014). Some of these frameworks, models, and theories were to address the issues of technology use, rejection, and acceptance (Gu et al. 2013), as well as to influence practice and research on how to implement technology into learning and teaching in such a manner that the desired results are achieved (Hamilton, Rosenberg & Akcaoglu 2016). According to Gu et al. (2013), much attention has been paid to teacher technology acceptance or rejection, but less attention has been paid to teacher and learner usage of technology in the classroom, on which most of the impact of using technology depends.

The theory of planned behaviour is a favourite among often-used and quoted models to anticipate human social behaviour since its inception 26 years ago (Ajzen 2011). This theory has been applied to a variety of fields, including politics, health care, and technology. It explains factors affecting human behaviour (Barnard-Bark, Burley & Crooks 2010; Conner & Armitage 1998; Davis 1989; Taylor & Todd 1995).

The academic social networking site ResearchGate recorded 22 citations on Theory of Planned Behaviour in 1985, and the number of citations grew steadily to a total of 4 550 in 2010. Based on a variety of indices, Nosek, Graham, Lindner, Kesebir, Hawkins, Hahn and Tenney (2010) found that Ajzen's Theory of Planned Behaviour has the top-ranking scientific impact score among Canadian and US social psychologists.

Likewise, since its introduction 27 years ago, the technology of acceptance model is among the most important quoted models to predict how the user accepts technology (Davis 1985). There are various settings where studies on technology acceptance have been applied, such as education (Bourgonjon, De Grove, De Smet, Van Looy, Soetaert, & Valcke 2013; De Smet, Bourgonjon, De Wever, Schellens & Valcke 2012; Pynoo, Devolder, Tondeur, Van Braak, Duyck, & Duyck 2011), health care (Pynoo, Devolder, Voet, Sijnave, Gemmel, Duyck, Van Braak, & Duyck 2013), and business (Venkatesh, Morris, Davis & Davis 2003). When TPB and TAM are integrated, the intention of teachers to utilise technology is postulated as a function of Facilitating Conditions (FC), Perceived Ease of Use (PEU), Subjective Norms (SN), Perceived Usefulness (PU), and Attitude towards Use (ATU) (Teo 2012).

The literature on teacher beliefs and how these beliefs link to change in practices, particularly on how to use ICT in the classroom, the factors affecting teachers' change in beliefs and practices regarding the use of ICT, the programmes designed to promote the use of ICT by changing beliefs and practices, as well as aspects to consider when conducting an ICT training programme, are all discussed in Chapter 2. The theories on which the study is based are discussed in this chapter. I also cover the Substitution Augmentation Modification Redefinition Model and the Technological Pedagogical Content Knowledge framework, both of which can be used to investigate how technology is integrated into learning and teaching

3.2 ORIGINS AND HISTORICAL DEVELOPMENT: THEORY OF PLANNED BEHAVIOUR

TPB was proposed by Ajzen (1985). It is an adaptation of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen 1975). Fishbein (1967) developed the TRA to discover the interplay between behaviour, intentions, and attitudes. The essential idea is that behavioural intention is the most important determinant of behaviour, as shown in the unshaded boxes in Figure 3.1 below. Individuals' behavioural intentions are directly influenced by subjective norms connected with a behaviour and attitudes toward doing the behaviour.

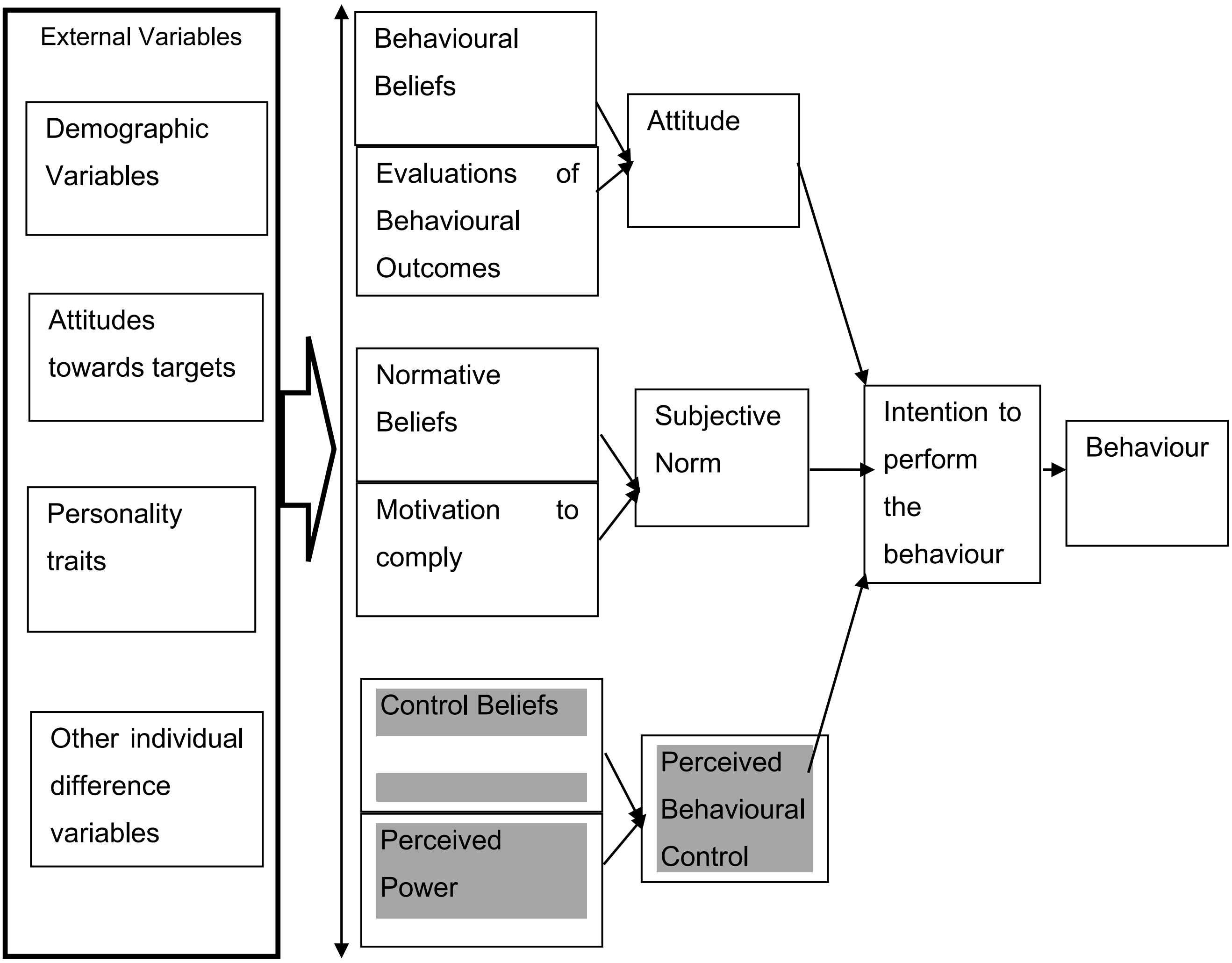


Figure 3-1: Theory of Reasoned Action (Fishbein, 1967) and Theory of Planned Behaviour (Ajzen, 1985).

NB: The Theory of Reasoned Action is shown by unshaded boxes and Theory of Planned Behaviour is shown by the entire figure.

The figure also indicates that attitude influences the individual's belief about outcomes of completing a behaviour, weighted by the evaluation of those outcomes. An individual who has a strong belief that a specific behaviour will result in undesirable consequences, is more likely to judge that behaviour negatively. A person who has a strong belief that performing the behaviour will give favourable outcomes, on the other hand, will have a positive attitude toward the behaviour (Montaño & Kasprzyk 2015).

A person's subjective norms are determined by his or her normative beliefs. When an important person disapproves or approves of specific behaviour, and a person feels highly driven to do what the important person demands, this is referred to as a subjective norm. A person has a negative subjective norm when he or she strongly believes that he or she should not execute the behaviour, and when he or she feels less driven to comply, he or she has a low subjective norm. Individuals have a positive subjective norm when they believe they should execute a specific behaviour and are motivated to do so (Montaño & Kasprzyk 2015).

The theory should be able to explain behaviour to a significant extent by putting behaviour under volitional control. The degree to which an individual can regulate his or her own behaviour is referred to as volitional control. The theory of reasoned action components is insufficient to predict behaviour when volitional control is diminished (Montaño & Kasprzyk 2015). Govender (2012) points out another flaw of the theory of reasoned action, it assumes that when a person decides to act, he or she would act freely and without restriction. In reality, there are obstacles such as unconscious habits, organisational or environmental constraints, time constraints, and restricted abilities that limit one's ability to act freely. As a result, Ajzen and Madden (1991) added perceived behavioural control to the TRA components (indicated in shaded boxes in Figure 3.1) to account for factors other than individual control that may impact behaviour and intentions, resulting in the Theory of Planned Behaviour (Montaño & Kasprzyk 2015).

Control beliefs influence the perceived behavioural control. Beliefs about the absence or existence of barriers and facilitators to complete a behaviour are referred to as control beliefs. Control beliefs are strongly weighed in terms of the perceived strength of each control factor's ability to prohibit or enable behaviour. The inclusion of perceived behavioural control is due to the fact that behaviour is determined by ability and motivation (Ajzen 1995). Intention, as well as a person's impression of control over their behaviour, are believed to have a direct impact on behaviour, particularly when volitional control is low and perceived behavioural control accurately reflects actual control over the behaviour (Montaño & Kasprzyk, 2015).

According to the theory, a person's attitude towards a behaviour, subjective norms, or perceived behavioural control are all independent determinants of a person's behavioural intention. When the subjective norm and attitude are constant, a persons' perception of the difficulty of a specific behaviour will influence the behavioural intention. Therefore, the relative relevance of these three elements in determining intentions should differ for individuals, populations and behaviours that are not the same. Most studies employ a direct measure of perceived behavioural control (Ajzen, 2006), while just a few have used the underlying measures of perceived power and control beliefs to operationalise perceived behavioural control (Montaño & Kasprzyk 2015). Fishbein and Ajzen (2010) later claimed that self-efficacy and perceived behavioural control are essentially the same theoretical construct.

Control beliefs, normative beliefs, and behavioural beliefs are linked to behaviour and behavioural intentions via perceived control, subjective norms, and attitudes in theory of planned behaviour and theory of reasoned action's causal chain. One of the key advantages of the theory of reasoned action/ theory of planned behaviour approach is the specification of postulated causal links among model components, as well as their measurement and computation (Bleakley & Hennessy 2012; Fishbein & Ajzen 2010; Hennessy, Bleakley, & Fishbein 2012). Other elements include environmental and demographic features, which are not thought to independently influence the likelihood of completing a behaviour (Montaño & Kasprzyk 2015).

3.3 THEORETICAL RATIONALE

The theory of planned behaviour is one of the most well-known social psychology theories that explains a variety of human behaviour-related phenomena. The theory assumes that a person's intention to conduct a specific behaviour has an impact on the behaviour. This implies that individuals will be more motivated to carry out the intended behaviour if they believe it would benefit them. The theory of planned behaviour further states that the psychological process of setting up a behaviour is influenced by intention, which is impacted by some fundamental beliefs (Ajzen, 1985; 1988; 1991). The intention is the pivot around which behaviour revolves, and it describes the level of effort that individuals are prepared to make to achieve a specific behaviour. Therefore, intention supports and captures people's actions as well as the motivational variables that impact their behaviour (Ajzen 1991).

Motivational variables can be used to further teach and entrench behavioural practices. Motivational variables are the driving force behind an individual's continued engagement in a learned behaviour. Motivational factors that influence intention include the individual's perceived behaviour control, subjective norms, and attitude toward the behaviour. We are one step closer to understanding why an individual performs a certain behaviour and, further, defining strategies to implant and propagate behavioural practices in society if we can comprehend these motivational variables (Ajzen 2011). The Figure 3.2 below illustrates four of the constructs of Theory of Planned Behaviour.

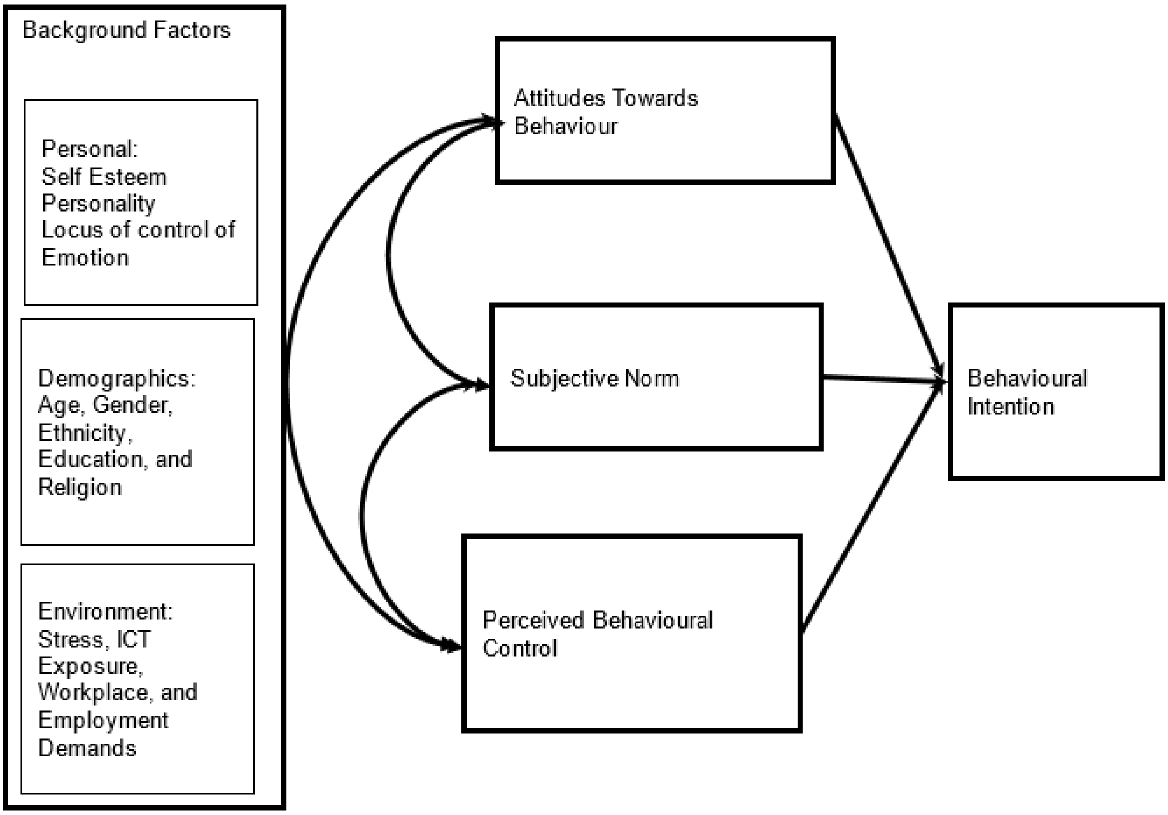


Figure 3-2: Theory of Planned Behaviour (Ajzen 2011).

3.3.1 Behavioural intention

Behavioural intention is a factor that captures how determined individuals are determined to carry out a specific behaviour (Asjzen 1991). In theory of planned behaviour, behavioural intention is the most effective predictor of behaviour (Teo & Tan 2012).

3.3.2 Attitude towards behaviour

The individual's negative or positive emotions towards executing a given behaviour are referred to as attitude toward behaviour. Attitude towards behaviour is determined by assessing individuals' views about the outcomes of a certain behaviour and evaluating the appeal of the behaviour in terms of those outcomes (Ajzen 2011). For example, if a teacher believes that using ICT would have a bad impact on his or her profession, he or she is likely to have a negative attitude toward it, therefore, he or she will be less inclined to employ it in his or her teaching (Lugano 2002; Reynolds 2001).

It is undisputed that teachers' attitudes towards computers are central for the successful use of computers in education (Shapka & Ferrari 2003). It does not matter whether the teachers' attitudes are negative or positive, learners' responses to the use of computer are affected by those attitudes. For instance, the teachers' approach towards the use of technology can affect the way that learners perceive the importance of the use of computers in their schools (Huang & Liaw 2005).

Computer experience (Teo & Tan 2012), computer fear or acceptance, computer expertise, gender, training, and computer confidence are all factors influencing attitudes toward the use of technology (Teo 2007). All these factors can engage with one another to change attitudes regarding the use of technology (Teo & Tan 2012). Teo (2010) investigated pre-service teachers' attitudes regarding technology use. He discovered that attitudes regarding the use of technology are directly determined by perceived technological complexity, subjective norms, perceived ease of use, and perceived usefulness.

3.3.3 Subjective norms

The perceived demands on an individual to engage in a certain behaviour, as well as the individual's motivation to obey such demands, are referred to as the subjective norm. The perceived pressure to conform has a strong correlation with an individual's behavioural intentions (Fishbein & Asjzen 1975). For instance, when a mandate is given by the school management that all teachers must use technology, the teachers may feel obliged to use it since a mandate has been given (Teo & Tan 2012). Sometimes individuals may perceive computers to be useful just because their co-workers have the same perception (Venkatesh & Davis 2000). Recent research such as Hopp (2013), Teo and Zhou (2014), and Zolait (2014) provides empirical support for Venkatesh and Davis's (2000) conclusion. Miller et al. (2006) further indicate that the school environment and culture need to be conducive, especially when the school leadership expect teachers to use ICT during teaching. This expectation and culture are established through good school leadership. Collaborative, inclusive school leadership is the type of leadership that communicates the expectation to use ICT (Scrimshaw 2004).

3.3.4 Perceived behavioural control

Perceived behavioural control is an individuals' perception of how difficult or easy a task is based on the possibilities and resources accessible to them (Ajzen 1991). Perceived behavioural control also refers to a person's perceptions about the presence of factors that may impede or facilitate the execution of the behaviour (Ajzen 2006). The extent to which perceived behavioural control affects behaviour through intention is thought to be influenced by the degree of actual control over the behaviour (Falko, Sniehotta, Justin & Vera 2014). For instance, the individual's willingness to adopt new technologies is less affected if they believe that the organisational infrastructure and technology resources to support and use the planned system are available. Therefore, perceived behavioural control represents the external constraints on the intention to adopt technology (Paul, Musa, & Nansubuga 2015). Miller et al. (2006) recommend that it is vital to reduce the factors that inhibit a teacher's perceived ability to use ICT, while strengthening those that help him or her do so. The government and schools should take action to address school-level problems that obstruct success.

3.3.5 Background factors

The most comprehensive and significant information about the factors that determine the behaviour in TPB, is contained in a person's control, normative and behavioural beliefs (Ajzen 2011). The theory does not specify where these behavioural, normative and control beliefs originate, it merely points to a host of possible background factors that may influence people's beliefs. These include personal factors such as personality and broad life values, demographic variables such as education, age, gender, and income, and exposure to media and other sources of information. Factors of this kind are expected to influence intentions and behaviour indirectly by their effects on the theory's more proximal determinants (Ajzen 2011).

Theory of Planned Behaviour proposes three mediation ideas. The first is that the impact of perceived behavioural control on behaviour is mediated in part by intention, but the effects of attitude and subjective norm on behaviour are totally mediated. Secondly, the impacts of control, normative, and behavioural beliefs on behaviour and intention are mediated by perceived behavioural control, subjective norms, and attitude, respectively. Thirdly, the effect of all other cultural influences, including medical, economic, environmental, social, and biological, is thought to be mediated by theory of planned behaviour components (Falko et al. 2014).

3.4 THE THEORY OF PLANNED BEHAVIOUR AND ITS USE

Theory of planned behaviour is largely considered to be a reliable model to explain the intention to utilise various technologies in various contexts. It also does well as a framework in various technology acceptance studies anchored in commercial settings, such as internet purchasing and the promotion of web-based e-commerce among small businesses, household technology adoption, and the decision to adopt telemedicine by healthcare providers (George 2004). Theory of planned behaviour is also utilised in studies where the purpose is to clearly comprehend the aim of intention in changing people's behaviour (Ajzen & Manstead 2007). Theory of planned behaviour is also used to describe which aspects of the human decision-making process are important when an individual decides to engage in specific behaviour, such as integrating ICT into education (Miller et al. 2006).

Venkatesh and Speier (1999) investigated how employees' moods affect the usage of new technology, intent, and motivation in the long and short term during new technology training. The theory of planned behaviour and theory of reasoned action measurements were adapted during their experiment. They found that negative moods during training resulted in a drop in plans to make use of technology and intrinsic motivation in the short and long term, even beyond active usage of the technology. On the other hand, positive moods during the training gave rise to a short-term boost in a desire to employ technology and intrinsic motivation, but these effects were not long-lasting.

Bosnjak, Tuten and Wittmann (2005) used the revised theory of planned behaviour to explain and predict participant numbers in a "five-wave" web-based panel study. A moral duty component was introduced to this investigation to gain more precise information regarding internalised moral rules.

3.5 TECHNOLOGY ACCEPTANCE MODEL

3.5.1 Origins and historical development: Technology Acceptance Model

The Technology Acceptance Model was proposed in 1985 by Davis. According to Davis (1985), external stimuli, linked to a system's characteristics and capabilities, have a direct impact on user motivation, which can predict actual system usage in the direction shown in Figure 3.3 below (Chuttur 2009).

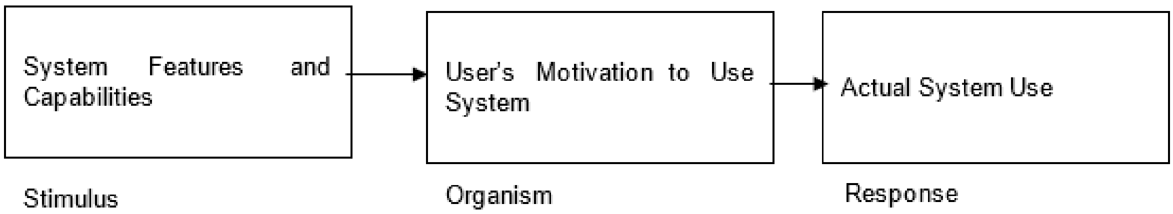


Figure 3-3: Conceptual model for Technology Acceptance (Davis 1985)

The technology acceptance model (TAM) was proposed after further refinement of the conceptual model, as seen in Figure 3.4 below. The modified model suggests that the motivation of the user may be described by three elements: attitude towards using new technology, perceived ease of use, and perceived usefulness (Davis 1985).

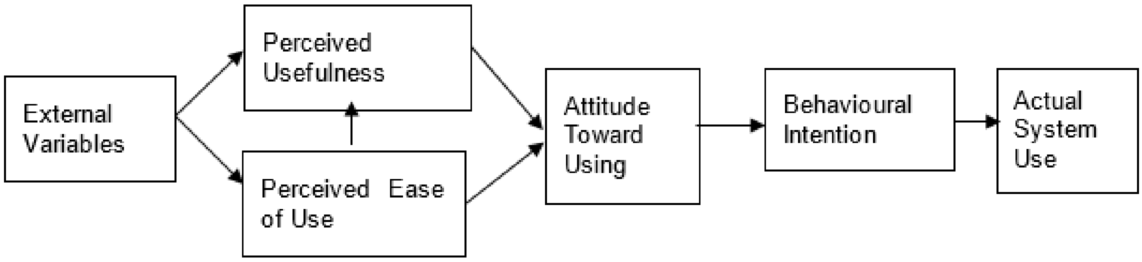


Figure 3-4: First Modified Model of Technology Acceptance Model (Davis, Bagozzi, and Warshaw 1989).

Davis et al. (1989) used the model in Figure 3.4 to gauge the intention of 107 participants to use a new system after one hour of introduction to the system, and again 14 weeks later. There is a substantial link between self-reported system usage and reported intention after one hour and after 14 weeks. It is worth noting that people's intentions are heavily influenced by their perception of usefulness.

Perceived ease of use was also discovered to have a small, tiny but substantial influence on behavioural intention, which eventually faded with time. Both perceived ease of use and perceived usefulness are demonstrated to directly influence behavioural intention. Since both perceived ease of use and perceived usefulness directly influence behavioural intention, the attitude construct was removed from the model shown in Figure 3.4 (Chuttur 2009). Figure 3.5 below indicates the final model.

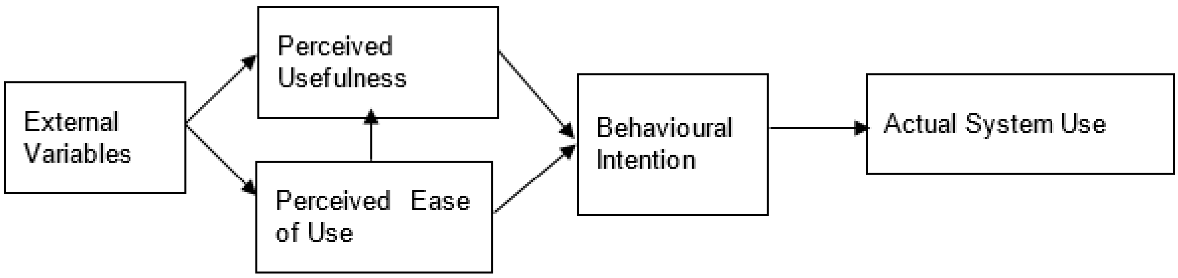


Figure 3-5: Final Version of Technology Acceptance Model (Venkatesh & Davis, 1996)

When the attitude construct is removed and behavioural intention is introduced, it is possible to understand how perceived usefulness influences actual technology usage. The presence of other factors that might impact a person's ideas about a system is another change made to the original TAM model. These factors are referred to as external variables. External variables include aspects such as the nature of the implementation process, user participation in design, user training, and system features (Venkatesh & Davis 1996). These external variables, according to technology acceptance model, influence both perceived ease of use and perceived usefulness (Alharbi & Drew 2014).

3.6 THEORETICAL RATIONALE

Technology acceptance model is among the most significant extensions of Ajzen and Fishbein's theory of reasoned action in the literature. The theory replaces many of the theory of reasoned action's attitude measures. The theory of reasoned action's attitude measures are replaced by technology acceptance metrics such as "usefulness" and "ease of use." Technology acceptance model and theory of reasoned action both have a high behavioural component. Technology acceptance model and theory of reasoned action presume that once an individual has the intention to act, the individual will be unrestricted in his or her actions. The information systems theory describes how people learn to utilise and accept technology (Govender 2012), and demonstrates the relationship between action, attitude, and belief (Chitungo & Munongo 2013). When end users are faced with an innovation or software package, the model suggests that various factors impact their decision about when and how they will use technology (Govender 2012).

3.6.1 Perceived usefulness

According to Davis (1989), perceived usefulness is the degree to which an individual believes that the use of a particular technology will lead to improved performance. This implies that possible adopters evaluate the outcome of their uptake behaviour based on the innovation's continued usefulness. Perceived usefulness is thought to have a considerable positive impact on users' intentions to use technology (Chitungo & Munongo 2013).

3.6.2 Perceived ease-of-use

Perceived ease of use is defined by Davis (1989) as the degree to which a user perceives that using technology requires no mental or physical effort. The perceived ease of use has an impact on teachers' acceptance of technology. When a teacher believes that using technology is free of mental and physical effort, for example, he or she will be easily motivated to use it frequently during teaching and learning. This could lead to better teacher performance (Davis 1989; Venkatesh & Davis 2000).

Exasperation might result from a lack of perceived usefulness in terms of technology, which can hinder its adoption. The impact of perceived ease of use on a user's propensity to adopt technology based on perceived usefulness has been well established (Davis 1989; Venkatesh & Davis 2000). Research has also shown that perceived ease of use influences one's behavioural intention, either indirectly or directly via perceived usefulness (Davis et al. 1989; Jackson, Chow & Leitch 1997). Since the inclusion of perceived ease of use, technology acceptance model has garnered a lot of attention. This demonstrates that technology acceptance model is an effective and reliable tool for comparing and evaluating technologies among different user groups (Farn, Fan & Chen 2006).

3.7 HOW TAM INFORMED LITERATURE IN THIS STUDY

Previous research such as Chau (1996), Mathieson (1991), and Adams, Nelson and Todd (1992), have shown TAM's high validity in assessing user technology acceptance. Teo (2010) investigated pre-service teachers' attitudes and beliefs regarding the use of computers. He discovered that attitudes and beliefs about computer use are directly influenced by perceived technological complexity, perceived ease of use, and perceived usefulness.

3.7.1 Measures for acceptance

The models of acceptance are used to anticipate and describe the variance in usage or user acceptance. The willingness shown by the user to implement information technology for the tasks it is intended to, is known as user acceptance (Dillon & Morris 1996). Even if various acceptance models have been developed and improved, there is a paucity of knowledge on how to properly measure acceptance. The most popular operationalisations for acceptance include use, behavioural intention, behavioural expectation, and attitude toward technology (Pynoo & Van Braak 2014).

3.7.2 Use

Use that is observed or self-reported can be assessed and operationalised in a variety of ways. The actual application of technology is regarded as evidence of acceptance (Pynoo & Van Braak 2014). Many technology acceptance model studies just measure observed use in a small number of people, or don't measure it at all (Turner, Kitchenham, Brereton, Charters & Budgen 2010). Observed use is quantified as the length of time spent using technology (Venkatesh et al. 2003), for example, by tracking the activities a person performs while finishing a task (Shapka & Ferrari 2003) or by logging in many times (Pynoo et al., 2011)

When data is acquired by observing how technology is used, respondents may raise concerns about their privacy, which can be a problem in some situations, such as hospitals (Duyck, Pynoo, Devolder, Adang, Vercruysse, & Voet 2008). Self-reported use of technology, on the other hand, can be quantified by the frequency, length, and intensity with which it is used (Venkatesh, Brown, Maruping, & Bala 2008). Pynoo et al. (2011) discovered that self-reported usage of technology can reliably predict secondary school teachers' login behaviour into their schools' intranet portal at various degrees of expertise with the portal, and at various times of the school year.

3.7.3 Behavioural intention

The centre of measurement for technology acceptance is a person's behavioural intention. Therefore, theory of planned behaviour, technology acceptance model, and other similar models are referred to as intention-based models (Venkatesh et al. 2003). Although the behavioural intention comes before the observed or self-reported use of technology, it was never really considered in technology adoption research (Pynoo & Van Braak 2014). In fact, behavioural intention has been shown to have limitations in predicting self-reported technology use, particularly in settings when technology use has become a habit (e.g. Duyck et al. 2008, Nistor, Schworm & Werner 2012, Pynoo et al. 2013, Pynoo, et al. 2012). For example, behavioural intention was not able to make a prediction of self-reported use in the investigations by Duyck et al. (2008) and Pynoo, Devolder, Duyck, van Braak, Sijnave, & Duyck (2012).

The items measuring behavioural intention are in most cases generally mentioned, without specifying the nature of use, e.g. “I intend to use the technology in the next months or weeks”. In a study by Nistor et al. (2012), a distinction between active and receptive use of technology is specified. Active is, for example, “I plan to contribute to the further development of the help system in the next month”, while receptive is “I intend to use the help system for information searching in the next months”. In cases where the technology has already been implemented, the intention can be used as the dependent variable (Pynoo et al. 2012), while in cases where it is still being planned, the intention can be used as the independent variable (Duyck et al. 2008).

3.7.4 Behavioural expectation

Behavioural expectation is linked to an individual’s intention to act in a particular way (Warshaw & Davis 1985a). Behavioural expectation, unlike behavioural intention, requires responders to consider the possibility of something getting in the way of the actual performance, and the intended consequence of the behaviour. Rather than behavioural intention, there is a considerable link between behavioural expectation and behaviour (Warshaw & Davis 1985b). Behavioural expectation is not commonly used since it overlaps with behavioural aim (Warshaw & Davis 1985a). When used as a distinct construct, it is able to anticipate the use (Venkatesh et al. 2008).

3.7.5 Attitude toward the use of technology

The attitude construct was included in the original edition of technology acceptance model. Over the years, as well as in educational settings, there has been debate on whether or not attitude should be included as a mediating variable between behavioural intention and predictor variables (Nistor & Heymann 2010; Teo 2009). However, in both voluntary (Teo, Lee, & Chai 2008) and mandatory situations (Brown, Massey, Montoya-Weiss & Burkman 2002; Pynoo et al. 2011), acceptance has been measured using attitude as a mediating variable. Users are not required to have hands-on expertise with the technology with the attitude construct, but in cases where the use of technology has been established, attitude can be beneficial (Pynoo et al. 2011). In contrast to behavioural intention, Pynoo et al. (2011) discovered that attitude could modestly predict intranet site usage in practice when teachers have around one school year’s worth of portal experience.

3.8 INTEGRATION OF TECHNOLOGY ACCEPTANCE MODEL AND THEORY OF PLANNED BEHAVIOUR

Both the theory of planned behaviour and technology acceptance model models are proven to be useful in predicting users' intent to use technology, although the theory of planned behaviour model provides developers with more specific guidance (Mathieson 1991). As opposed to technology acceptance model, which focuses on perceived ease of use and perceived usefulness, the theory of planned behaviour, which focuses on intention, can provide researchers and teachers with a more comprehensive understanding of belief systems, which can aid in overcoming technological problems (Smarkola 2008; Teo & Noyes 2011).

There are three major distinctions between technology acceptance model and theory of planned behaviour. The first distinction is that theory of planned behaviour focuses on beliefs that are unique to each circumstance, with the assumption that a number of beliefs may generalise to other situations while others may not. Technology acceptance model, on the other hand, assumes that ease of use and usefulness are the most important factors influencing usage decisions. Secondly, theory of planned behaviour is more detailed in determining social variables than technology acceptance model, and thirdly technology acceptance model only looks at ease of use in terms of technology, but theory of planned behaviour can be applied to any behaviour (Siragusa & Dixon 2009). Theory of planned behaviour can give precise information about each of its components that may be relevant to a specific set of individuals (Siragusa & Dixon 2009), while technology acceptance model, on the other hand, is useful for acquiring broad information on people's attitudes toward a system (Siragusa & Dixon 2009).

TAM has two limitations, according to Dishaw and Strong (1999) and Park (2010). The model pays minimal attention to identifying variables that may have an impact on perceived usefulness and perceived ease of use. Secondly, while the model is beneficial for identifying factors that influence users' technology use and acceptance, Park (2010) points out that it cannot provide explanations why people use and accept a certain technology. As a result, the integrated technology acceptance model and theory of planned behaviour model is used to predict teachers' intention to use information communication technology in their classrooms in this study. Figure 3.6 below shows the integration of TAM and TPB.

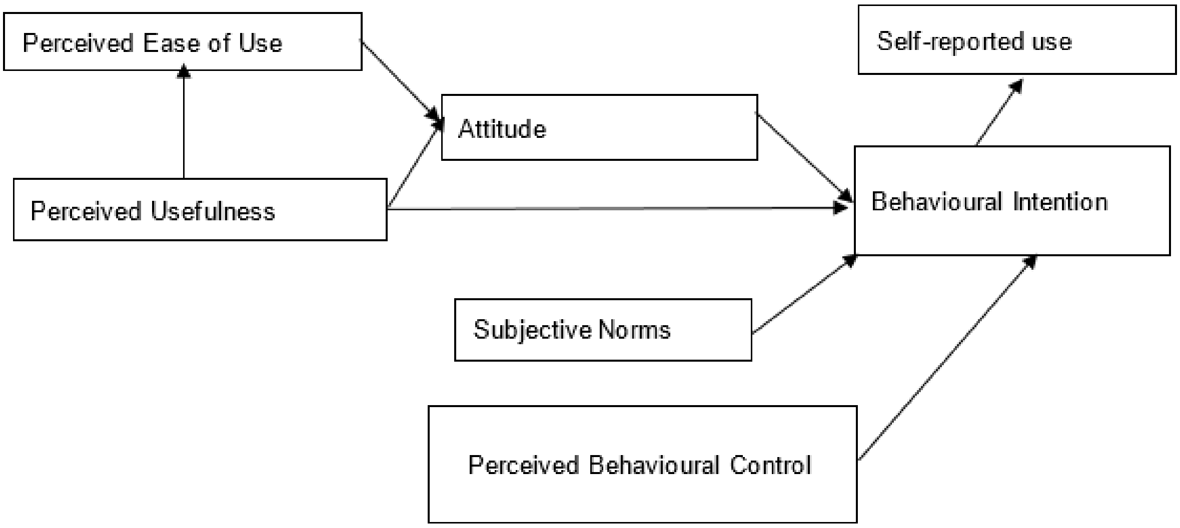


Figure 3-6: Integrated model of Technology Acceptance and the Theory of Planned Behaviour (Pynoo & Van Braak, 2014)

3.9 MODEL TO EVALUATE LEVEL OF TECHNOLOGY USAGE: SUBSTITUTION AUGMENTATION MODIFICATION REDEFINITION (SAMR)

Puentedura (2006) created the Substitution Augmentation Modification Redefinition (SAMR) model, which is a four-level taxonomy-based strategy to analyse, use, and select technology. SAMR is a recent addition to educational technology professional development and teacher learning (Hamilton et al. 2016). According to a report published by the International Society for Technology Education (ISTE) (2015), the term "SAMR" was used in only one of the almost 800 sessions during the 2013 ISTE conference. Out of nearly 900 total sessions, the 2014 conference agenda includes 30 "SAMR"-related workshops and presentations. "SAMR" was mentioned in only 44 of the 1 000 sessions at the 2015 ISTE conference.

The primary goal of the SAMR model, as shown in Figure 3.7 below, is to help teachers understand the levels at which technology integration can be used during teaching, help teachers to integrate technology in their classes, and to categorise and describe teachers' usage of classroom technology (Puentedura 2006). The nature of the model encourages teachers to "move up" from low to high degrees of using technology during teaching. The simple design of the model gives teachers the opportunity to expand their abilities in order to fully comprehend the complexity involved in successfully implementing technology in the classroom (Hamilton et al. 2016).

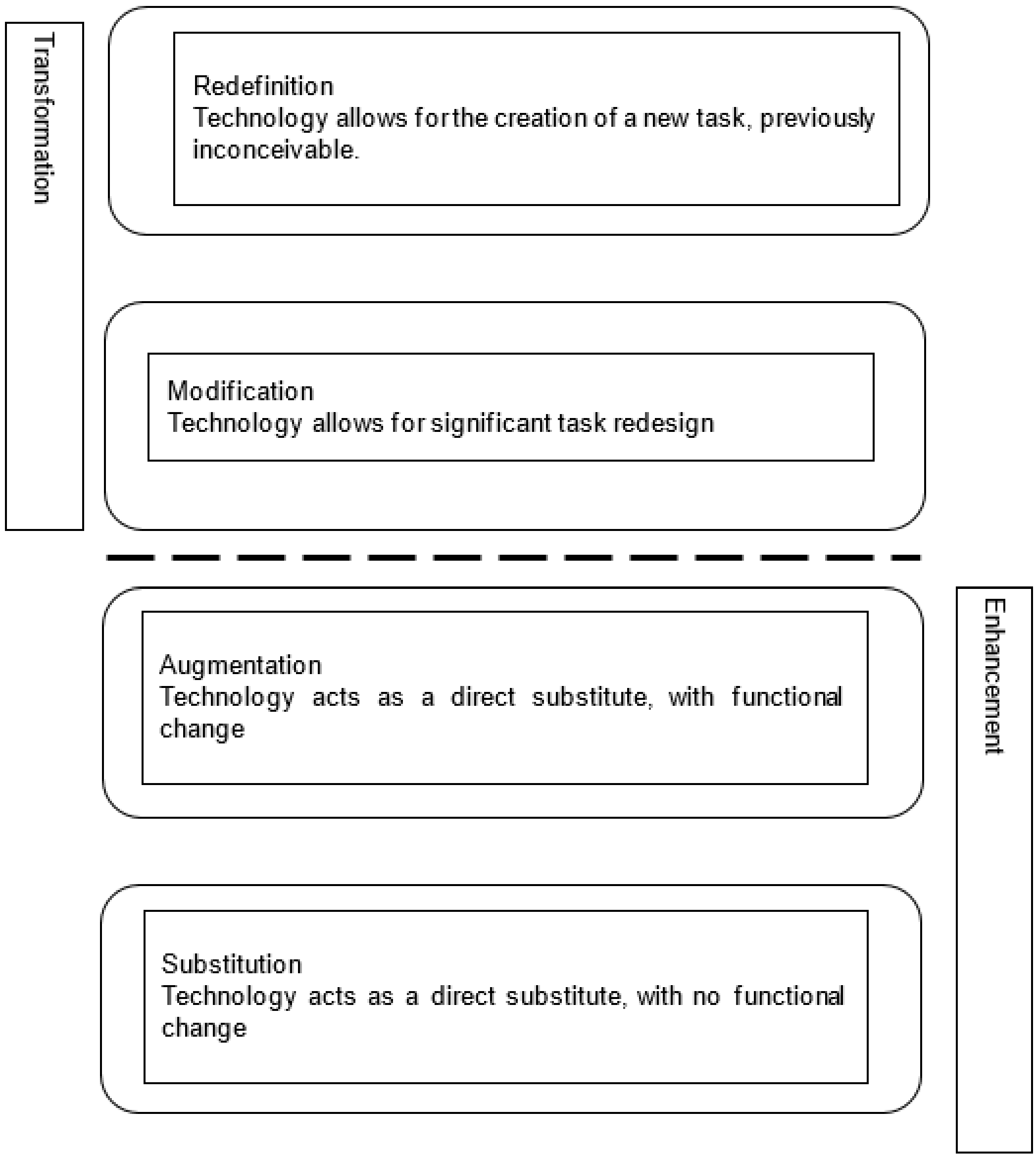


Figure 3-7: Substitution, Augmentation, Modification, and Redefinition (SAMR) model (Puentedura 2006)

3.9.1 Substitution

At this stage, the traditional approach of teaching is directly substituted by teaching using technology. In simple terms, it is a direct, bare-bones replacement. Analogue technology substitutes digital technology, with no "functional change" (Puentedura 2014). Brown (2015), for example, compares the substitution to a cup of coffee from a coffee shop replacing a cup of coffee made at school or at home. The fact is, it is still coffee and there is no real change. Other examples include instead of using pencil and paper to write note, Evernote or a similar product can be used to write notes. The substitution level can also include a learner presenting information about an article using slides, Prezi, PowerPoint or Keynote (Brown 2015).

3.9.2 Augmentation

At the augmentation level, Brown (2015) indicates that it is as good as taking a standard cup of coffee and making it better by sprinkling a small amount of cinnamon or cream on top. The truth is that the coffee has not really changed, only the flavour has, as it now contains additional ingredients that have improved and augmented the original.

Examples of augmentation include learners photographing objects in the classroom and classifying them, if the learners are studying Mathematics or Science. A second example is that learners can complete a fluency boot camp by filming themselves reading a chapter from a book, and playing it back to check for proficiency and articulation using a video camera app. One last example is that learners can annotate images using applications such as LibreOffice (Brown 2015).

3.9.3 Modification

The integration of technology can wholly revamp a task. Instead of exhibiting a graphic of how light travels, a variable-based online interactive simulation of light that can be adjusted can be presented to learners in a secondary science lesson (Hamilton et al. 2016). At this level, various bells and whistles are added to the augmented coffee. Whipped cream, caramel, and certain specific flavourings are combined to create a sophisticated salted caramel mocha (Brown 2015).

Significant task redesign using technology includes the addition of interactive media via movie, audio, and sound, the creation of a soundtrack in GarageBand for a visual presentation, the use of the iMovie app to create iMovie Book Trailers, or digital stories using the Videolicious app, and real-time collaboration using Google Drive. The tasks are changed in such a way that they are personalised for each learner (Brown 2015).

3.9.4 Redefinition

At the redefinition level, according to Brown (2015), it is similar to changing the definition of a typical cup of coffee to something else that can be found only in the coffee shop. At this level, work cannot be accomplished without the aid of technology. Redefinition is compared to higher order thinking levels such as evaluating, generating, and analysing, as found in Bloom's Taxonomy (Brown 2015).

Learners can connect with classrooms all over the world, and not only their own. They can also collaborate, share and do research at this level. Questions are generated, and topics and content are explored by learners using the technology available to them. Learners further develop problem-solving skills, critical thinking, and develop mapping by using the software Mystery. Collaborative writing is completed through Mystery Skypes and through Kidblog, and social media like Twitter connects them to the world (Brown 2015). Teachers expand their horizons beyond the four walls of their classrooms to take Virtual Field Trips to chat with Nasa astronauts, to add to their space unit using Google Connect Classrooms, Hangouts and virtual book club discussions (Brown 2015).

3.10 SAMR MODEL RATIONALE: LEARNING IS THE OUTCOME, TECHNOLOGY IS JUST A TOOL

The greatest benefit of the SAMR model is its ability to move teachers beyond the normal four walls of their classrooms and introducing learners to inspiring new levels of learning (Portnoy 2018). When the model is effectively used, great thinkers and problem solvers will be developed, learning could be transformed outside and inside the classroom, and limitless opportunities and achievement of the four C’s, as seen in Figure 3.8 below, could be achieved. It is important to note that true redefinition only takes place when there is a shift in focus from apps to content (Brown 2015).

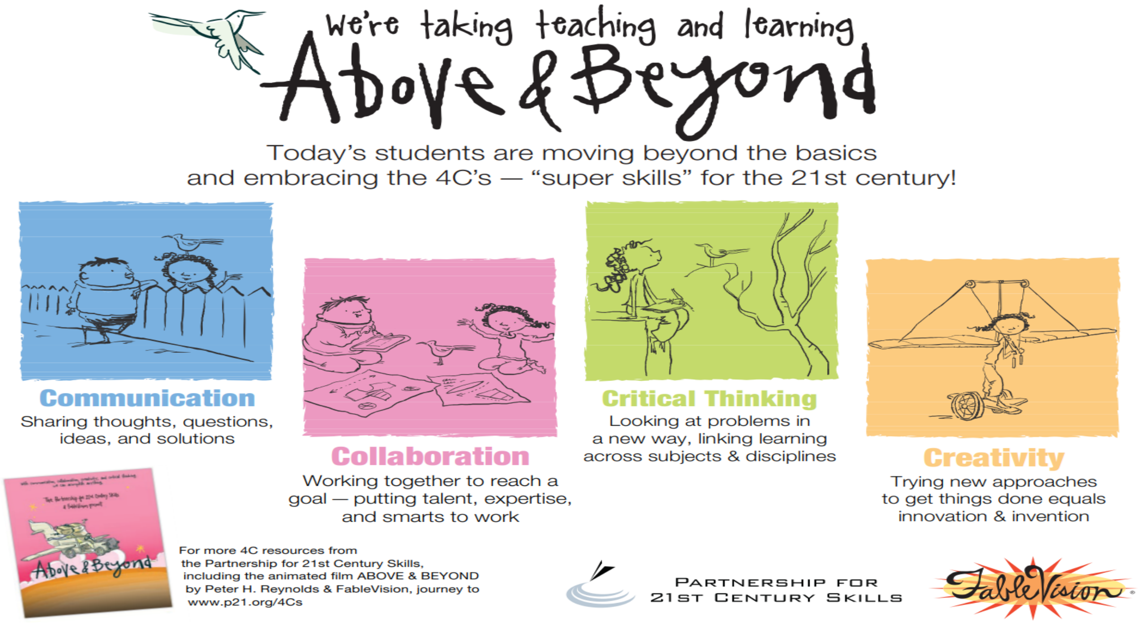


Figure 3-8: 4 C's (Brown 2015)

3.11 TECHNOLOGY INTEGRATION FRAMEWORK: TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

Shulman's definitions (1987, 1986) of Pedagogical Content Knowledge (PCK) serve as the foundation for the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK explains how PCK, and teachers' knowledge of educational technologies, interact to provide effective technology-assisted teaching. Mishra and Koehler (2006) initially proposed the framework to describe an integrated relationship between pedagogical knowledge, subject knowledge, and technological knowledge to aid the possible integration of ICT tools in school activities and in the classroom. TPACK is usually depicted as a Venn diagram with three overlapping circles of knowledge, as seen in Figure 3.9.

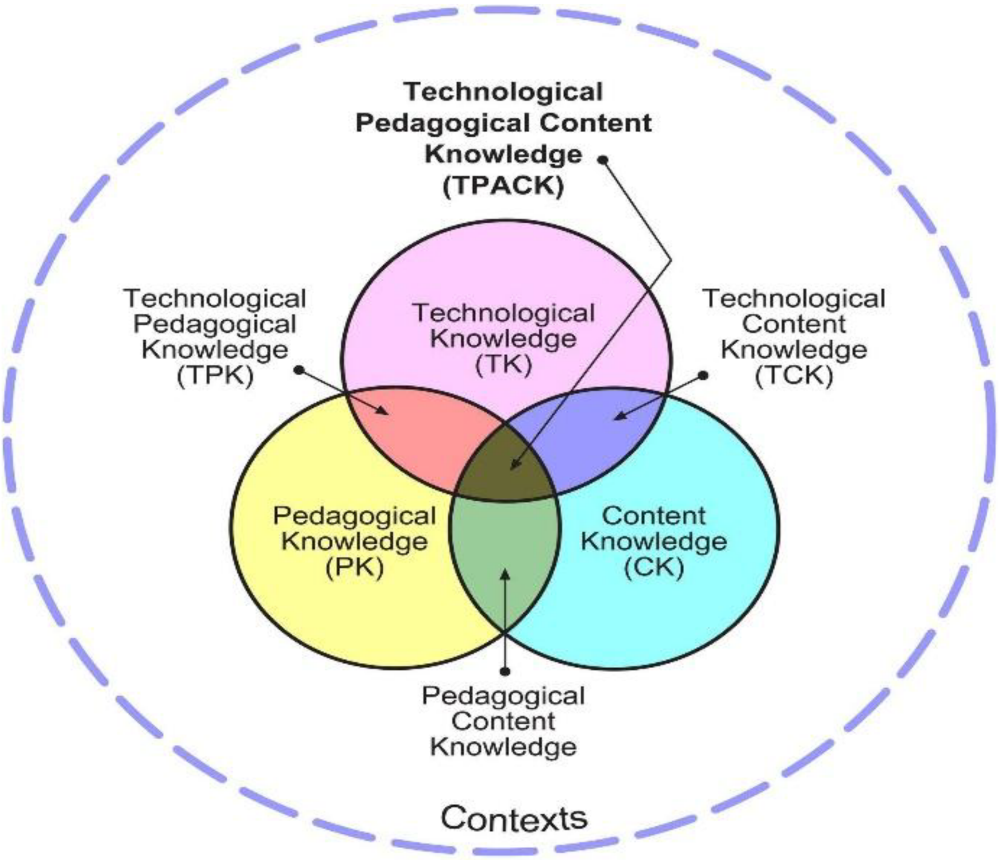


Figure 3-9: TPACK Framework (Mishra & Koehler 2006)

3.11.1 Content knowledge

The concept of content knowledge describes the teacher's grasp of the subject matter. This is the most important type of knowledge in teaching (Mishra & Koehler 2009). Knowledge of ideas, theories, organisational structures, and concepts are included in content knowledge. Content knowledge also comprises proof and evidence of knowledge, as well as recognised methods and processes for acquiring such knowledge. It is important to understand the deeper knowledge basics of disciplines in which teachers teach, because the nature of inquiry and knowledge differ greatly across domains (Shulman 1986). For example, in science this would include knowledge of evidence-based reasoning, understanding of the scientific method, and knowledge of scientific facts and hypotheses (Mishra & Koehler 2009). This can be costly for teachers who do not have a broad background of content understanding. For instance, learners may create misconceptions about the content area, and may obtain inaccurate information (National Research Council 2000; Pfundt & Duit 2000).

3.11.2 Pedagogical knowledge

A teacher's pedagogical knowledge refers to his or her detailed understanding of the practices, methods, and processes of learning and teaching. This type of knowledge is used in the assessment of learners, lesson design, classroom management, and student learning. Pedagogical knowledge also comprises knowledge of classroom procedures or techniques, as well as tools for assessing learner comprehension and the nature of the target audience. To comprehend how learners gain skills and create information, as well as how they establish good attitudes and habits of mind towards learning, a teacher must have extensive pedagogical expertise. Therefore, teachers must be aware of developmental, social, and cognitive learning theories, as well as how they can be applied to children in the classroom (Mishra & Koehler 2009).

3.11.3 Pedagogical content knowledge

PCK is related to and consistent with Shulman's concept of knowledge of pedagogy pertaining to the teaching of specific content. A central element of Shulman's PCK conception is the way in which subject matter is modified during teaching. According to Shulman (1986), transformation occurs when teachers find new ways of presenting and interpreting material, as well as tailoring or adjusting the educational material to consider the learners' views and experiences. This transformation is emphasized by Mishra and Koehler (2009) when they outline what makes teaching effective, namely looking at things differently, alternative teaching strategies, creating connections between content-based ideas. For all of this, prior knowledge is essential, as is an awareness of misconceptions and ways to view them. Mishra and Koehler (2009) also say that the PCK includes basic concepts of learning, teaching, assessment, and curriculum, as well as the connections between curriculum, assessment, and pedagogy, and the conditions that encourage learning (Mishra & Koehler 2009).

3.11.4 Technology knowledge

According to Mishra and Koehler (2009), describing technological knowledge is difficult since there is a risk of the definition becoming obsolete. They do say, however, that the description of technological knowledge is virtually identical to the one of Fluency of Information Technology (FITness), as suggested by the National Research Council's Committee on Information Technology Literacy (NRC 1999). As stated by FITness, technological knowledge is defined as being able to recognise when technology can act in a negative or positive manner toward achieving a goal, adapt to changes in technology on a regular basis, and be able to utilise this knowledge for personal and professional purposes. This implies that, for problem-solving, communication, and information processing, it is vital for a human being to have a deeper grasp and command of information technology than the classic definition of computer literacy implies. When technological knowledge is acquired in this way, an individual can develop new ways to complete a task and to use information technology to complete a range of tasks. Technological knowledge is conceptualised as a progressive process, emerging during a lifetime of open-ended, generative contact with technology (Mishra & Koehler, 2009).

3.11.5 Technological content knowledge

The link between content and TK is long and storied. Physics, archaeology, medicine, and history are among the fields that make use of current technologies that enable the manipulation and depiction of information in a novel and useful manner. New metaphors for comprehending the universe and new perspectives for interpreting events have also emerged because of technological advancements, such as viewing the brain as an information-processing computer and the heart as a pump. These metaphorical and representational links are not just for show, and they have often resulted in fundamental shifts in the character of a discipline (Mishra & Koehler 2009).

Technical content knowledge (TCK) is understanding how content and technology interact. In addition to mastery of the subject matter that they teach, teachers must also have a thorough understanding of how the subject matter are impacted by technology. In addition to being aware of and understanding appropriate technologies for teaching a subject in their domain, teachers must also be aware of how the content is dictated to by technology, or vice versa (Mishra & Koehler 2009).

3.11.6 Technological pedagogical knowledge

Technological pedagogical knowledge (TPK) consists of a theoretical understanding of how learning or teaching might be affected when certain technologies are utilised in a certain way. This necessitates a thorough comprehension of the pedagogical restrictions and benefits of various technological tools. TPK requires a better understanding of the affordances and limits of technology, , as well as their disciplinary contexts (Mishra & Koehler, 2009).

Because a whiteboard is usually static, but accessible to many people, it is commonly used in classrooms. As a result, it is mostly placed in the front of the classroom and is under the teacher's control. This placement forces a specific order in how the classroom should be set up. The setup defines where chairs and tables should be positioned, as well as the nature of learner-teacher interaction. In this case, learners can only utilise the whiteboard when called on by the teacher to do so. However, it is erroneous to think that there are no other ways in which whiteboards can be used. In an advertising agency, for example, a whiteboard is used in a different way during a brainstorming session. Anyone in the group can utilise it, and it serves as a focal point for meaningful negotiations, construction, and discussion. The whiteboard in this situation is not under the control of a single person (Mishra & Koehler, 2009).

Understanding the benefits of technology, and how they could be used differently depending on changes in purposes and context, is an important part of grasping TPK. This knowledge is vital because most popular software packages have not been designed for educational purposes. Software programs like MSN Messenger, Entourage, Excel, PowerPoint, and Word, for example, are designed to be used in business settings. Web-based technologies such as podcasts are designed for communication, social networking, and entertainment purposes. It is critical that teachers gain the ability to see beyond the most prevalent uses of technology, and configure them for instructional applications that are unique to them. Therefore, TPK needs the creative, forward-thinking, and open-minded application of technology in order to increase student learning and comprehension (Mishra & Koehler 2009).

3.12 TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE RATIONALE

The interaction of content, pedagogy, and technological knowledge leads to TPACK understanding. TPACK is not the same as knowing all three concepts separately. TPACK is the foundation of effective technology-assisted education. It necessitates the understanding of how technology can be used to build on existing knowledge to develop new epistemologies or strengthen old ones, an understanding of learners' prior knowledge and epistemological theories, as well as an understanding of what makes concepts difficult or easy to learn. It also focuses on how technology can assist learners in solving some of their problems (Mishra & Koehler 2009).

Teachers immediately bring TPACK into action when they blend content, pedagogy, and technology expertise while teaching. There is no single technology solution that applies to every teacher, every course, or every perspective on education because each situation is a unique blend of these three aspects. The solution is derived from a teacher's ability to get through the areas indicated by the three aspects of technology, pedagogy, and content, as well as the complex interplay between various variables in certain situations. If the relationships between the components and each knowledge component on its own are disregarded, it might result in oversimplified failures or solutions (Mishra & Koehler 2009).

Teachers should therefore develop cognitive flexibility and fluency, not only in the essential domains of Content (C), Pedagogy (P), and Technology (T), but also in the interrelationships between these contextual characteristics and domains in order to design effective solutions. Consider TPACK as a professional knowledge construct if you have a sophisticated, pragmatic, adaptable, and thorough understanding of teaching with technology. It is tough to teach with technology, and it is even more difficult to do it successfully. Continuous development, maintenance, and the re-establishment of a dynamic balance among all components is essential to properly teach with technology. It is crucial to note that a variety of factors determine how this equilibrium is achieved (Mishra & Koehler 2009).

3.13 COMPARISON OF SAMR AND TPACK

The TPACK framework is designed to help teachers prepare for successful technology integration by not separating technology training and comprehension. Rather, TPACK transforms technology into a vital ally of content and pedagogy in the learning process. The purpose of the TPACK evaluation is to assess teacher self-efficacy when it comes to content, pedagogy, and technology in the creation and delivery of learning experiences. The SAMR approach, on the other hand, considers the competence level of teacher regarding the use of technology in the classroom. It is all about how well a teacher integrates and uses technology in individual tasks and in the classroom.

SAMR and TPACK are inextricably linked, with each framework contributing to the other's success. Teachers' usage of technology, for example, will be governed by which level of the SAMR model the planned activity best leverages as they design learning experiences using the TPACK framework (Humes 2017).

Table 3-1: Synopsis of the findings on the theoretical framework based on the Theory of Planned Behaviour and Technology Acceptance Model, SAMR model and TPACK framework

Issues	Literature suggests	Section
Theory of planned behaviour	When teachers believe that the use of ICT will result in positive outcomes, they will have a positive attitude towards it.	3.2 &3.3
	If a teacher believes that using ICT for teaching would negatively affect his or her profession or the learning process, the teacher's attitude will be unfavourable.	3.3.2
	Teacher attitude is central to the success of using computers.	3.3.2
	Attitudes find their roots in beliefs.	3.3.5
	Variables such as computer confidence, training, gender, knowledge about computers, and computer experience influence teacher attitudes towards computers.	3. 3.2
	Teachers feel the need to use ICT when school leadership approves, encourages and expects them to use it to teach.	3.3.3
	When the school infrastructure required to use technology is available, the intention to adopt and use it will not be an issue.	3.3.4
Theory of planned behaviour	School factors that impede the use of ICT should be minimised, while those that facilitate teachers' ability to use ICT should be strengthened.	3.3.4
	Intention and behaviour is indirectly influenced by the effects of external factors, including demographic variables such as age, gender and education.	3.3.5
	Positive emotions during training improve the intention and intrinsic motivation to utilise the technology in the near future.	3.4
	Negative moods during training lead to lower intentions and intrinsic drive to use technology.	3.4
Technology of	Perceived simplicity of use as well as perceived usefulness have a direct impact on behavioural	3.5

acceptance model	intention.	
	The beliefs that a person holds towards the use of ICT are influenced by external variables.	3.6
	The perceived usefulness of technology has a big influence on whether or not people want to use it.	3.6.1
Technology of acceptance model	The essential elements for technology acceptance and use are perceived usefulness and perceived ease of use.	3.6.2
	ICT usage, behavioural intention and attitude towards technology are classified as measures of technology acceptance.	3.7.2, 3.7.3 &3.7.5
	ICT usage can be observed or self-reported.	3.7.2
	Self-reported use is a good predictor of how frequent teachers log in and use technology.	3.72
Behavioural expectation	Participants think about what might happen between the intention and the actual performance.	3.7.4
Integrated model of TPB and TAM	Due to differences and limitations in both TPB and TAM, the study is guided by the integrated model of TAM and TPB.	3.8
SAMR model to evaluate level of technology usage	Substitution	3.9.1
	Augmentation	3.9.2
	Modification	3.9.3
	Redefinition	3.9.4
Technology integration framework: TPACK	Content knowledge	3.11.1
	Pedagogical knowledge	3.11.2
	Pedagogical content knowledge	3.11.3
	Technology knowledge	3.11.4
	Technological content knowledge	3.11.5
	Technological pedagogical knowledge	3.11.6
	Continuous development, maintenance, and re-establishment of dynamic balance among all components is essential to properly teach with technology.	3.12

3.14 CONCLUSION

Theory of planned behaviour and technology acceptance model are two of the many models that have been developed from disciplines like sociology, information systems, and psychology. Individuals' intentions to accept new technologies have been explained using these models (Davis 1985; Ajzen 1985). In a variety of contexts, the technology acceptance model has been widely used to identify the factors of technological uptake (Davis et al. 1989). The main purpose of the technology acceptance model is to identify and predict the system adjustments that must be done in order for users to adopt technology. The TPB model, on the other hand, is utilised to achieve a better understanding of how beliefs and attitudes connect to people's intentions to perform (Yucel & Gulbahar 2013). The theory of planned behaviour model could also be used to illustrate the decision-making process of someone who accepts and uses information technology (Lu, Huang & Lo 2010).

Teachers' comprehension of technology is crucial in order for them to use it effectively. This concept must be stressed in any model or framework related to teaching with technology (Inserra & Short 2012). Instead of concentrating on “moving up” a techno-centric, hierarchical model, teachers are required to thoroughly plan for instruction that offers meaningful technology-based learning experiences to learners (Hamilton et al. 2016). The research methods and methodologies used to perform this study will be outlined in the following chapter.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 INTRODUCTION

The theoretical frameworks and models that informed the study were discussed in Chapter 3. This chapter gives an overview of the research methodologies and data gathering tools used. Details about the participants and the data collection and analysis techniques are also provided. The steps required to assure the validity, reliability, and trustworthiness of the data are discussed before the chapter concludes with a discussion of the ethical considerations of the study.

4.2 OUTLINE OF THE RESEARCH STUDY

The study was conducted in nine stages to answer the research questions and realise the aims of the research. This is depicted in Figure 4.1.

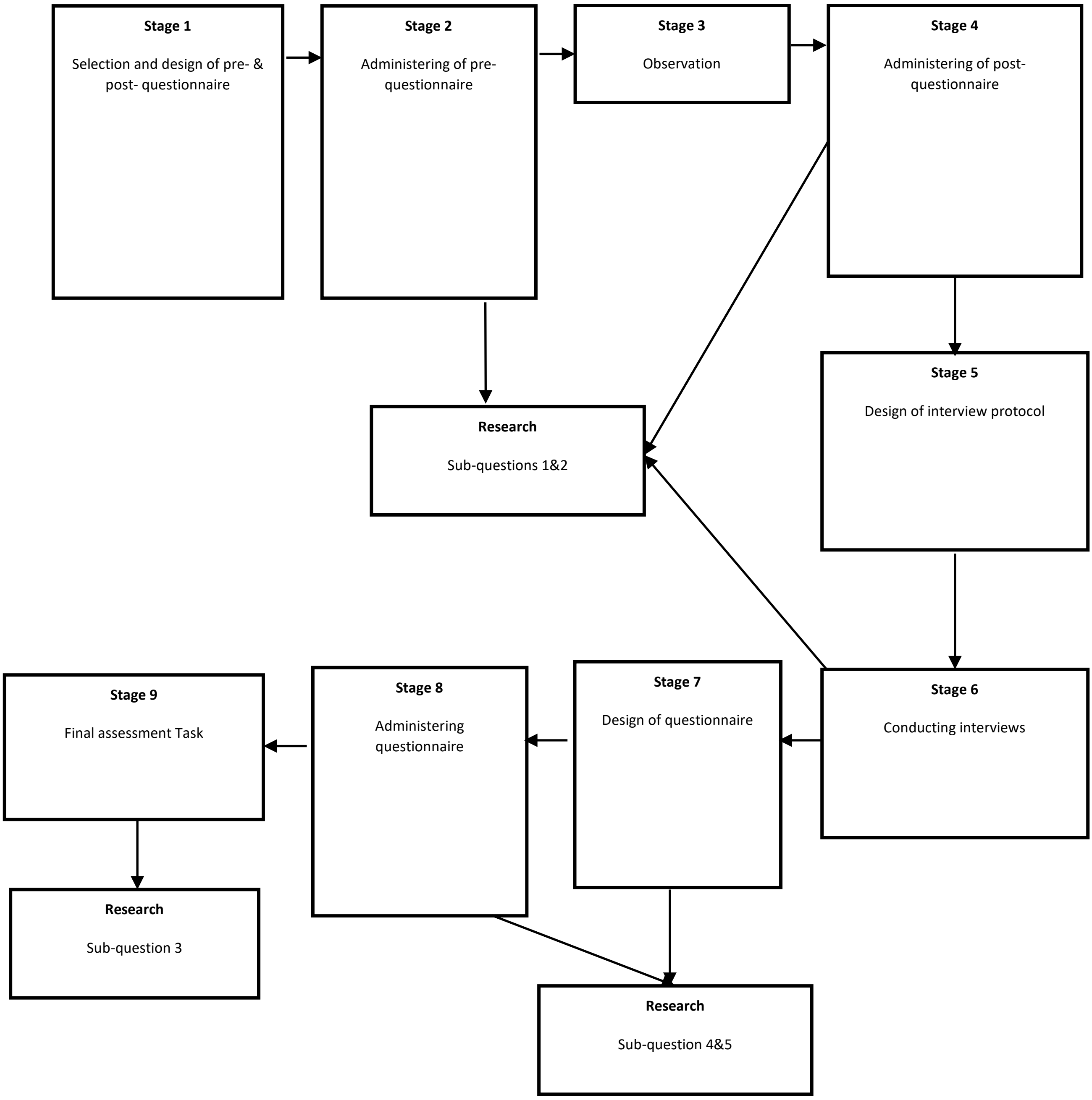


Figure 4-1: Outline of the research study

- Stages 1, 2, 4, and 6: selection, design, questionnaire, and interviews

The first and fifth stages involved the selection and design of the pre- and post-questionnaires, and interview protocol to answer research sub-questions 1 and 2. In the second, fourth and sixth stages, a mixed methods approach (Creswell 2012) was followed, where sequential quantitative survey data and qualitative semi-structured interview data were collected. The pre-questionnaire was administered to a large group of teachers (N = 53) to determine their perceptions and practices towards ICT usage. The post-questionnaire, that included teachers' biographies, was administered to a large group of teachers (N = 53) to determine how teachers' perceptions change and how age, gender, qualifications, teaching experience, school location, school quintile, and school factors are related to the extent to which teachers' perceptions change through the course of a professional development opportunity based on TPACK principles.

The pre- and post-questionnaire responses were analysed quantitatively using the paired t-test method. I compared teachers' perceptions before and after the training to determine how their perceptions regarding the use of computers changed over the course of the professional development opportunity aimed at promoting TPACK. ANCOVA one-way method was used to understand how biographical factors are related to the extent to which teachers' perceptions changed over the course of the professional development opportunity regarding the use of ICT. Pre- and post-questionnaire responses about their practices were used to select the teachers (N = 17) who participated in the interviews. Responses from interviews were used to understand the quantitative results in detail. The interviews were audio recorded and transcribed. The qualitative data analysis software package NVivo 12 (QSR International 2012) was used to code the interview transcriptions and to aid observations of trends in the data regarding changes in beliefs and practices of teachers regarding the use of ICT in Physical Sciences education during the programme.

- Stage 3: observation

The fourth stage of the study involved observation (Sauro 2015), where I observed as a participant for the duration of the programme. Observation as a participant involved observing how teachers interacted with the presenters, amongst themselves, teachers' attitudes in general, possible trends displayed in the confidence of teachers regarding the use of technology, and progress displayed in terms of the learning that might have occurred. I interacted minimally with the participants to better understand how they felt about the programme and progress made. Observing as a participant also helped me to identify possible teachers to be interviewed in stage 7. Field notes were taken for each session and analysed qualitatively by using NVivo 12, a qualitative data analysis software package (QSR International 2012). Codes were used to package data to determine the patterns and trends to make meaning of the qualitative data.

- Stages 7 and 8: design, interviews, and questionnaire

Stage 7 involved the design of the questionnaire protocol. To answer sub-questions 4 and 5, qualitative data was collected in stage 6 and quantitative data was collected in stage 8. A mixed-method approach (Creswell 2012) was followed, where sequential qualitative semi-structured interview data and quantitative survey data were collected. Semi-structured interviews were conducted with a small group of teachers (N=17) after stage 4. For me to determine issues that arose during the programme, and how teachers responded to such issues, I first conducted interviews and then I administered a survey to a larger group of teachers (N = 53) (vide 1.6.3). I used NVivo 12, already explained previously to analyse the qualitative data. Codes were used to classify qualitative data to determine those issues that arose during the programme, and how teachers responded to the identified issues.

- Stage 9: Final assessment

Stage 9 involved teachers submitting the final required assessment task at the end of the programme. Sixty-nine teachers submitted the task, but for consistency with the pre- and post-questionnaire data, I included only the final assessment tasks of the 53 teachers who completed both the pre- and post-questionnaires as data in this study. In this task, teachers had to design a Physical Sciences lesson, present the lesson to their learners, and reflect on its success. Instructions on what was expected in the task are found in the Appendix 7. Teachers were requested to give evidence of what happened in the class by uploading photos and videos from the lesson. The task was utilised to answer sub-question 3.

4.3 RESEARCH PARADIGM

After qualitative and quantitative research, mixed methods research is considered the third methodological movement. It is difficult to develop a corresponding philosophical paradigm to mixed method research (Johnson & Gray 2010). According to previous research, the most suited paradigm for doing mixed methods research is pragmatism (Howe 1988; Tashakkori &Teddlie 1998; Patton 2002; Maxcy 2003; Teddlie & Tashakkori 2003, 2006; 2009; Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Johnson 2006; Morgan 2007; Denscombe 2008; Scott & Briggs 2009; Johnson & Gray 2010; Creswell & Plano Clark 2011).

In contrast to a critical realist approach to mixed methods research, a pragmatic approach has less influence on philosophical assumptions regarding the conduct of research methodologies. In this way there is less restriction regarding how researchers can carry out research. In this instance, rather than choosing between the positivist or post-positivist or constructivist paradigms, to answer research questions, pragmatism analyses "what works" (Johnson & Onwuegbuzie 2004; Onwuegbuzie & Johnson 2006). However, this does not imply that mixed methods are used aimlessly “such that anything goes” (Denscombe 2008, p 422). They should be utilised with caution (Bryman 2006; Freshwater 2007; Denscombe 2008), combining and selecting the results of suitable approaches to reply to research questions, as in this study.

Pragmatism is an alternative that supports both constructivist and positivist/post-positivist paradigms, together with research questions that establish the degree to which qualitative and quantitative methods are utilised (Teddlie & Tashakkori, 2009). Using a mix of qualitative and quantitative methods to reply to research questions, provides a middle ground both methodologically and philosophically (Johnson & Onwuegbuzie 2004; Onwuegbuzie & Johnson 2006), as seen by a variety of mixed methods research designs (Teddlie & Tashakkori 2009; Creswell & Plano Clark, 2011).

> *“Pragmatism includes a healthy dose of pluralism by which it means that it is not logically contradictory to claim that quantitative and qualitative research are both useful, even if, at times, they appear to be contradictory; perhaps what is seen as contradictory are different perspectives that are complementary and enable one to more fully to see his or her world”* (Onwuegbuzie & Johnson 2006, p. 54).

The application of mixed methods research in pragmatism begins with the establishment of research questions that may be answered by combining the results of qualitative and quantitative research (Creswell & Plano Clark, 2011; Tashakkori &

Teddlie, 1998). Rather than emphasising the methods themselves (Teddlie & Tashakkori, 2009; Creswell & Plano Clark, 2011), the study emphasises a value system in which researchers choose the proper approaches to answer to research questions, as is the case in this study.

The pragmatic approach, such as critical realism (Modell 2009), uses abduction to transition between induction and deduction, while qualitative and quantitative research use induction and deduction respectively, to relate theory to facts. While qualitative research is subjective and quantitative research is objective, a pragmatic approach to research challenges the traditional dichotomy between subjectivity and objectivity when doing research. It is the belief of the pragmatists that at some stage during the research, by avoiding interacting with subjects, an objective approach will be taken, while at other stages the subjective approach will be taken by interacting with research subjects to construct reality (Teddlie & Tashakkori 2009). Researchers are allowed to be adaptable in order to respond to the study questions in the most practical way possible. Qualitative and quantitative research will be used to determine the singular and numerous realities in this study (Rorty 1999; Creswell & Plano Clark 2011).

4.4 RESEARCH DESIGN

This is a case study using a mixed methods approach. It involves quantitative and qualitative research methods to determine how South African teachers' perceptions change with regards to the use of ICT when they experience subject-specific professional development opportunities based on TPACK principles. A study investigating such complexity needs to allow for different approaches – both quantitative and qualitative – to adequately explore the phenomenon.

Mixed methods design refers to research in which the investigator collects and analyses data, integrates the findings, and makes inferences utilising both qualitative and quantitative methods in a single study of inquiry (Tashakkori & Creswell 2007). A mixed methods study allows for a more comprehensive and in-depth grasp of the subject at hand, compared to a single method approach (Johnson, Onwuegbuzie & Turner 2007; Greene 2007). The mixing of qualitative and quantitative methods in one study can help give enough information to explain the divergent aspects of the studied phenomenon, while at the same time minimimsing or excluding potential alternative explanations of the results (Plano-Clark & Ivankova 2017).

4.5 STUDY POPULATION

The study population comprise of the individuals, dyads, groups, organizations, or other entities that a researcher seeks to understand and to whom or to which the study results may be generalized or transferred and is the principal group about which the research is concerned (Casteel & Bridier 2021). In this study the population comprises South African physical sciences teachers. Although the convenience sample used in this study (vide 4.7.) is not representative of this population, the likelihood that valid lessons can be learned from the sample, and applied to the broader population, is enhanced by the wide range of biographical characteristics of the sample, as discussed in 4.7.

4.6 RESEARCH METHODS AND DATA COLLECTION TECHNIQUES

Pre- and post-questionnaires and were designed in stages 1 and 7. Quantitative data were collected in stages 2, 4 and 8 using the questionnaires. Interviews, observations, and the final assessments were used as qualitative data collection tools. The design features, limitations, and affordances of these data collection methods are discussed below.

4.6.1 Survey (including how survey was drafted)

4.6.1.1 Questionnaires

A set of comprehensive structured questions used by a researcher to obtain specific information from participants is referred to as a questionnaire. Questionnaires are the most cost-effective way to collect quantitative data in a relatively short period. Structured questionnaires give a measure of perceptions, attitudes, opinions, and feelings about issues of particular concern to the researcher and allow the researcher to explore the topic in detail. Structured questions can also be used to identify patterns and trends that demand further investigation using qualitative methods. However, feelings and emotional responses of the participants cannot be fully captured by questionnaires. It is possible that meaningful data can go unnoticed (Debois 2016).

4.6.1.2 Questionnaire design

The purpose of the questionnaire in this study was to capture the change in teachers' perceptions regarding the use of ICT, how biographical factors are related to the extent to which teachers' perceptions changed through the course of the professional development, and what issues arose during the professional development. My goal of the questionnaire was to maximise reliability and validity of the questionnaire in order to maximise the quality of the data. The overall design features, specifically in terms of addressing design limitations, are highlighted below.

One of the most important limitations in using questionnaires as tools is that questionnaires cannot fully capture emotional responses or the participants' feelings, and useful data can go unnoticed (Debois 2016). To address this limitation, a Likert scale questionnaire with a rating scale of 1 – 5 was used. Scale rating of 1 – 5 allowed for strength and assertion. Secondly, a variety of types of questions were included for teachers to express their perceptions, practices, and issues that arose during the professional development opportunity.

Closed questions usually dominate structured questionnaires, as they provide data that can be quantitatively analysed for trends and patterns. The agenda is completely predetermined by the researcher, with minimal room for participants to qualify their responses. Open-ended questions, on the other hand, are based on open questions, allowing respondents to react in their own terms. This allows them to provide more detail in their responses, irrespective of the researcher's predetermination of the sequence and topic (Debois 2016).

Pre- and post-questionnaires in stages 2 and 4 used closed questions on a five-point Likert scale. The closed questions were clustered in accordance with their relevance to theory of planned behaviour and technology acceptance model constructs as seen in Appendix 3. By answering the closed questions teachers could express their beliefs and practices. Through closed questions teachers could comment on the programme and its contribution towards using ICT. Closed questions also enabled me to examine the patterns and trends that assisted to describe what is going on in the educators' daily work experiences with ICT. I was able to generate better quality data. Analysis of the closed questions required a coding scheme, with accompanying measures to ensure inter-rater reliability and accuracy of application of the coding scheme. In stage 8, the questionnaire consisted of both open and closed questions. Open-ended questions allowed teachers to elaborate on what issues arose during the professional development, how these issues affected them, and how they responded to these issues. This enabled rich feedback that revealed explanations of what was going on, as well as any ideas, attitudes, feelings, perceptions, and concerns that arose unexpectedly.

All questionnaires were designed in such a way as to include contexts familiar to the teachers. The teachers completed the pre-questionnaire at the beginning of the programme and the post-questionnaire at the end of the programme. Several strategies were employed to ensure a high response rate. For example, in cases where teachers could not complete the questionnaire during a session, they were allowed to complete it in the next session. Where teachers missed a post-questionnaire, I emailed it to them.

Coverage error is another limitation when using surveys (Dillman Smyth & Christian 2014; Singleton & Straits 2009; Check & Schutt 2012). A sample can never be fully representative of the population it represents, and sample bias will always be present to some degree. A wide range of teachers, each with their own teaching experiences across the range, participated. Teachers from urban, township and rural schools and quintile 1 to 5 schools participated. However, an unequal representation of the categories was seen in the group of teachers. There were for example more teachers from township and rural schools than from urban schools.

When questionnaires are used there is a chance that some questions will be ignored, which impacts on the reliability and representability of data (Debois 2016). Uncertainness about the meaning of some questions may lead to the non-response of participants. Answers are sometimes selected without thoroughly reading the alternative answers or even the question. Participants may make split-second decisions or skip questions, impacting the quality of the data. In the data collected, all teachers made an attempt to answer all of the questions.

The main aim of standardised questionnaires is to include tested and well-designed questions that have the same meaning to all participants. Language and social and cultural differences can, however, influence interpretation. Visser, Krosnick and

Lavrakas (2000) therefore indicate that measurement error needs to be considered when designing questionnaires. Piloting the questionnaire is an important component of questionnaire development, as it reduces measurement error. The first step is usually to conduct an expert review to screen items and ensure unambiguous wording, after which a field test or pilot is done (Krosnick & Presser 2010). Methods that do not employ pilot testing can only provide insight into possible problems after the data comes in, whereas methods that include pilot testing can provide information about actual problems. In the design of this questionnaire, validated items were used to compile the questionnaire to limit ambiguity in the wording of questions, and ultimately limit measurement error.

4.6.2 Interviews (including justification for the interview schedule)

An interview is a data collecting process in which one person, the interviewee, is questioned by another, the interviewer (Polit & Beck 2006). Interviews can be conducted either by telephone or face-to-face. The in-depth qualitative exploration of individuals' perceptions that cannot be obtained from questionnaires can be provided by a well-designed and conducted interviews. Interviews allow the exploration of perceptions, emotions, thinking, assumptions, and attitudes, which may be encouraging the observed behaviour of individuals involved in the learning and teaching transformation in some way. They can further confirm interpretations or follow up on unexpected results of various data collection and analysis methods (Polit & Beck 2006).

The focus of this study was not only to capture how teachers' perceptions regarding use of ICT changed, where necessary, but also to gain insight about how teachers learned in the programme, which activities they found most valuable, and outcomes, e.g. whether they implemented what they had learned during the programme. For this purpose, semi-structured interviews were chosen as the most appropriate data collection tool. Semi-structured interviewing is a method that consists of a dialogue between researcher and participant, guided by a flexible interview protocol and supplemented by follow-up questions, probes and comments (Dejonckheere & Vaughn 2019).

Semi-structured interviews provided opportunities to explore those aspects that could not be observed directly, such as feelings, intentions, and thoughts. Semi-structured interviews were important in this study because it was difficult to observe situations when the observer was not present, how people have organised their world and the meanings they attach to what happens in their world. Semi-structured interviews allowed me to enter the participants' perspective. Interviewer-respondent interaction is a complex phenomenon. The physical characteristics, attitudes, predispositions, and biases that affect the data and the interaction, are brought to the interview by both parties as explained below.

4.6.2.1 Interviewer bias

Respondents can easily be distracted by the presence of an interviewer. Respondents are usually more prone to provide socially desirable and positive responses when an interviewer is present. Respondents are also often reluctant to disclose beliefs which are not likely to be validated by the interviewer. Interviewers have varying abilities to use techniques to aid and recall recording responses, to probe adequately, to listen and to sound and appear neutral (Bowling 2005). I was known to all the interviewees through my previous position as a Physical Sciences subject advisor and provincial subject coordinator in the Free State province. I have been part of the programme from the beginning to the end.

To reduce researcher bias, I used semi-structured interviews. In the semi-structured interviews, a mix of more and less structured questions was used. There was no set order, and the interview was mostly guided by a list of questions. All questions were utilised flexibly, and participants were requested to provide precise information.

4.6.2.2 Social desirability bias

During an interview there is social interaction with another person. This can lead to interviewees taking social norms into consideration when they respond, which can result in social desirability bias. Social desirability bias occurs when interviewees present themselves in the best possible light, which can lead to either under-reporting or over-reporting undesirable behaviours. This can cause confusion in relationships by weakening, moderating, or inflating them (Bowling 2005). I made an effort to explain the value of their contribution to the study to the teachers, and I assured them that their identities would not be revealed and that they would not be identifiable by how I use their responses in the report. Teachers were free to choose between a Friday or a Saturday for their interview and could also state a preferred time.

4.6.2.3 Sampling bias

Interviews can be with individuals or with groups. Unlike an interview between the interviewer and the interviewee, where the interviewer acts as moderator, group interviews take place when a group of people are interviewed together using an exploratory and flexible discussion format highlighting the interactions between the participants (Qu & Dumay 2011). In this study, interviews took place in a group setting. The primary benefits of group interviews are convenience and time. Relative to individual interviews, there tends to be less researcher-bias since the researcher is less involved in the discussion (Doyle 2004). However, sampling bias can occur when the sample does not accurately represent the population. To minimise sampling bias, the selection of teachers was guided by the participation of teachers during sessions, and progress made during the sessions (highly participating, medium, and non-participating teachers). Teachers were further selected based on more experienced, medium experienced and less experienced teachers, teachers from quintile 1 to 5 schools, and teachers from urban, township and rural schools. More details about the interviewees are provided in Table 4.2.

4.6.2.4 Interview protocol design

It is undisputed that an interview is "a complex and involved procedure" (Minichielle, Aroni & Hays 2008, p. 1). There is no “recipe” for designing appropriate and insightful questions. The purpose of the interview protocol was two-fold: firstly, to allow teachers to express and articulate their prior usage, prior beliefs, and prior practices, compared to their practices, beliefs, and usage after the short learning programme. Secondly, to express how they generally feel about the programme, relating to aspects such as the scope of the programme, facilitation, duration of the programme and the impact of the programme on their teaching.

To break the ice between the group members who, in most instances knew one another, I allowed them to introduce themselves to the group. I encouraged the group members to engage in a free-ranging discussion, as the main purpose of the interview was for them to make me understand their beliefs about ICT usage. I also wanted to find out how often they had used computers or tablets or laptops in their teaching before the programme, and how this had changed after the programme. I also wanted them to reflect on the programme itself. The group members were assured that their answers would be treated with confidentiality. Each member group was given time to respond freely and in a relaxed manner to the questions. Each member could substantiate or give a different version of the point under discussion. This was allowed because they all came from different contexts. Each member responded to the same question in his or her way. Toward the end of the interviews, general comments and observations were invited from the participants.

4.6.3 Observation (including explanation of the observation tool)

As cited by Koh (2016), Marshall and Rossman defined observation as an ordered account of artefacts, behaviour, and events in the social setting chosen for the study. The observation further affords the researcher an opportunity to observe how participants act separately and together. Rather than self-reported metrics, it is a more reliable measurement of actual participant behaviour (Koh, 2016). In this study, observations allowed me to observe the actual behaviour and attitudes of teachers. The quality of initial behavioural analysis based on demographics was improved during observations, therefore increasing the validity of the research.

Various types of observations are discussed below (Koh 2016).

a) **Descriptive observation:** In this type of observation, the researcher produces a lot of data, of which some can be irrelevant and some relevant to the study at hand. The researcher notes down everything that occurs as he or she observes.

b) **Focused observation:** In this type of observation, only the material that is relevant to the study is analysed by the researcher. An example includes tracking the gaze of a participant, or the facial expressions of a participant when trying to perform a specific task.

c) Selective observation: Specific activities are observed by the researcher, such as how participants browse through the menu on a website.

In this study, descriptive observation was used. I was part of the programme for its duration. The behaviour, attitudes, participation, and progress of teachers towards technology usage were intensively observed. Field notes were used to note down everything that occurred during the sessions. Observations made during the sessions guided me in selecting teachers to participate in the group interviews.

Sauro (2015) identified four observational roles during observational research.

1. Complete observer

The role of the researcher is a detached one, meaning that the observer is neither noticed nor seen by the participants. Because the participants are unaware that they are being observed, they are more likely to respond normally. However, ethical questions such as possible deception are likely to be raised by this role. For example, how would a person feel when he or she finds out that he or she has been watched without knowing?

2. Observer as participant

The role of the researcher is recognised and known by the participants. In many cases, the research goals of the observer are known by the participants. The interaction between the researcher and the participants is limited, despite the fact that there is interaction. It is the researcher’s aim to be as neutral as possible.

3. Participant as observer

The researcher fully engages with the participants. The researcher is not a neutral third party, but more of a colleague or a friend. The presence of the researcher is known by participants.

4. Complete participant

The role of the researcher is almost like a spy. The researcher takes part in the participants’ activities, and fully engages with them. However, the participants are not aware that research and observation are being conducted, even though there is full interaction between them and the researcher. It is sometimes referred to as "going native," in the context of performing indigenous fieldwork.

In this study, I was an observer as participant. I was formally introduced to the group of Physical Sciences teachers, and the study goals were disclosed to the teachers. This was to minimise the ethics of observing bias, as this is a major issue in observational research. Unlike scientific study, however, Jorgensen (1989) claims that "participant observation does not contain human beings" (p. 28; emphasis in original). Observing as a participant afforded me the opportunity to describe the Physical Sciences teachers' behaviours, attitudes, and intentions in detail, and the opportunity for naturally viewing participation in unscheduled events.

Slack (2001) points out that whatever form an observation may take, ranging from the informal to the formal, or formal to the informal, in all cases it is crucial that the observer be aware of the psychological and physiological factors that may determine how observations are interpreted. There are a range of preconceptions of how observers observe. When other methods are used to cross-check these perceptions, there is a likelihood that bias can be reduced. To minimise the observer's bias, questionnaires, semi-structured interviews, and the final assessment as data collection tools were used to validate the observations.

According to Schensul, Schensul, and Lecompte (1999), observations are filtered by interpretive frames, and "the most precise observations are fashioned by formative theoretical frameworks and careful attention to detail" (p.95). The researcher's ability to observe, document, and analyse what is observed has an impact on the quality of participant observation. In the early stages of research, it is critical for the researcher to make detailed observation field notes from the population under investigation, rather than from the researcher's imposed predetermined classifications. I was part of the programme with no preconceived ideas, just like the other Grade 10 Physical Sciences teachers who completed the programme. To this effect, a pre-determined set of observation questions were drawn up which, as the programme continued, was adjusted due to the observed behaviour in the programme (Appendix 6).

I continually discussed the observations with the facilitator of the programme to improve the reliability and validity of my observations. This was done to identify areas of disagreement and agreement so that my observational data would be more reliable and trustworthy. I further assumed a neutral position during the sessions. The field notes were analysed using NVivo 12 (QSR International 2012). Codes were used to classify qualitative data to capture key observations during sessions (Appendix 11).

4.6.3.1 Observation tool design

The design of the observation tool was guided by the questions what, why, how, and when. In addressing what, the observation tool was designed for Grade 10 Physical Sciences teachers who underwent a short learning programme in the use of ICT. The why was to answer the posed research questions, especially research questions 1 - 3. In addressing how, the tool was designed in such a way that observations could be done in all the sessions, as the observer participant role was assumed by the researcher, and descriptive observation was used. Lastly, in addressing the when, as indicated above the observation design tool was designed to enable the researcher to observe everything in all the sessions during the SLP.

4.6.4 Document analysis (including framework for analysis)

Through the final assessment, I could decide what practices the teachers displayed in their use of ICT towards the end of the professional development opportunity. Therefore, it formed one of the data collections tools in this study.

4.6.4.1 Moderation of final assessment task

I anticipated that the teachers would develop their lessons in a way that was in line with the TPACK framework. I therefore used the TPACK framework to moderate their lessons. The TPACK framework is based on the understanding and application of three categories of knowledge linked to technology, pedagogy, and content (Koehler, Mishra, Kereluik, Shin & Graham 2014). I used the TPACK framework to moderate the teachers' final assessment tasks. I was able to recognise the convergence of these parts of teacher knowledge as a means of effectively teaching with technology and was able to articulate it (Koehler et al. 2014).

Effective teaching with technology necessitates an awareness of the mutually reinforcing links between all three aspects when used together to generate representations and context-specific, suitable techniques (Koehler, Mishra & Yahya 2007). However, teachers need to go beyond just having technological, pedagogical, and content knowledge to be able to design appropriate technology-based lessons

(George & Sanders 2017). Shulman (1987 p. 13) explains that "teachers must use their knowledge base to provide the grounds for choices and actions". He calls this process "pedagogical reasoning and action".

To determine whether the 53 teachers in the sample could design technology-based lessons, I analysed the implemented lessons that the teachers submitted for the final assessment of the short learning programme. I used Tables 4.2 and 4.3 found in Appendix 9 to analyse the designed and implemented technology lessons. The first column in both Tables 4.2 and 4.3 shows six components of the TPACK framework and their brief descriptions. The second column shows the activities per six components of the TPACK framework observed during the analysis, and the third column shows the number of lessons in which the components of the TPACK framework were covered in each teacher's lesson. Analysis of the technology-based lessons provided a new perspective on what teachers know and think about technology, as well as their design capacity (Dorner & Kumar 2016). It further illustrated their intentions based on lesson planning, their opinions and beliefs (Costa 2016; Koh & Chai 2016; Koh, Chai, & Tay 2014; Tallvid 2016), and their reasoning and practices (Almerich, Orellana, Suárez-Rodríguez & García 2016; Archambault & Crippen 2009; Hinostroza, Ibieta, Claro & Labbé 2016; Koh, Chai & Tsai 2014).

The analysis of the 53 technology-based lessons revealed that 38 of the 53 teachers could design and implement lessons that are consistent with the TPACK framework, while 11 of the 53 teachers could design and implement lessons that consisted of PCK, PK and CK. Four of the 53 teachers did not submit their lessons. The results of the analysis of the technology-based lessons imply that 38 teachers who could design and implement lessons that are consistent with the TPACK framework, have acquired the required skill and knowledge to design and implement the technology-based lessons. They demonstrated that they could apply the acquired skill and knowledge to design technology-based lessons. Eleven teachers designed and implemented lessons consisting of PCK, PK, and CK. The decision of the 11 teachers to not include the TK, TPK, and TCK in the design of their lessons, should not be ascribed to the assumption that they did not acquire the necessary skill and knowledge to design technology-based lessons consistent with the TPACK framework. It might instead mean that they decided not to include TK, TPK, and TCK in their lessons, since their strongest knowledge areas were CK, PK, and PCK. Archambault and Crippen (2009) argue that teachers rate the components CK, PK and PCK as their strongest knowledge areas, as they were taught these components during their pre-service training.

The use of CK, PK and PCK, and the non-use of TK, TPK and TCK of 11 teachers cannot be attached to acquired or non-acquired skill and knowledge. I therefore, assume that the teachers' beliefs and attitudes affected their intention to use ICT in their design and implementation of technology-based lessons. As with other research that employed the TPB to explain teachers' beliefs, practices, and attitudes, Ajzen and Madden (1986) and Venkatesh et al. (2003) claim that teachers' intention to use ICT are influenced by their beliefs, practices, and attitudes. The other reason for not using TK, TPK, and TCK might be that they were told that they did not have to use ICT.

There are two key factors when teachers design technology-based lessons. The first is the knowledge of the teachers about technology-related matters in the teaching of their subject, and the second is the competency levels of teachers when their knowledge and design and technological competencies are applied. Almerich et al. (2016) believe that meaningful use of ICT will occur when teachers have acquired the required skills and expertise to go beyond merely substituting ICT for traditional ways. Teachers' ICT-related beliefs and attitudes are affected by frequent application of skills and knowledge consistent with the TPACK framework. Therefore, it is important that teachers become more skilled so that their attitudes and beliefs can change. When ICT innovators focus on teachers' attitudes towards a specific behaviour, and what they believe about the behaviour, there is a better probability of success (George & Sanders 2017).

The SAMR model was used as the basis for designing a tool to categorise the technology use implementation levels of the 38 teachers who used technology in their lessons. I designed a spreadsheet that contained the four elements of the SAMR model, namely substitution, augmentation, modification, and redefinition. I used the teachers' self-reported accounts and their final assessment tasks, regarding how they had used ICT during their lesson, to make a judgement about which of these categories best described the teachers' ICT usage in the described lesson. As seen in Figure 4.2 in Appendix 10, 20 teachers used technology at the substitution level, 12 teachers used technology at the augmentation level, three teachers used technology at the modification level, and three teachers used technology at the redefinition level. Table 6.8 gives a detailed classification of how the 38 teachers used ICT in this study.

4.7 SAMPLING

A sample is a small proportion of the population that is selected as representative of the entire population. There are two types of sampling, namely non-probability (purposive and convenience) sampling and probability (random) sampling. In non-probability sampling, some individuals have no chance of selection while in probability sampling, all people have the same chance of being selected (Nigam 2013). Conclusions drawn from a non-probability sample cannot be inferred from the sample to the whole population (Surbi 2016), while conclusions drawn from probability samples can be generalised to the target population (Nigam 2013).

Different sampling methods were utilised in this study:

- All 86 participants of the programme answered the pre-questionnaire, but only the 53 who were present at the session, near the end of the programme, at which the post-questionnaire was administered, answered this and were therefore conveniently used as the sample whose quantitative data were analysed. These 53 are not representative of the 86 participants since they do not include those who dropped out of the programme, and they are not representative of the population of South African Physical Sciences teachers, since these 53 were able, and prepared, to participate in and complete, the programme.

- Purposive non-probability sampling was used to establish a group through which semi-structured interviews were carried out. No generalisation of the findings was needed, as the sample was chosen for a specific purpose.

- I observed all participants in the programme, as I participated as an observer.

- For consistency, only the final assessment task of the 53 teachers who had completed both pre- and post- questionnaires, were analysed, despite 69 of the original 86 participants having completed this task.

Table 4.1 below summarises the demographic information of the survey sample.

Table 4-1: Demographic information for a survey sample

<table>
<tr><td colspan="4">Gender</td></tr>
<tr><td>G</td><td colspan="2">Frequency</td><td>Percent</td></tr>
<tr><td>Female (F)</td><td colspan="2">28</td><td>52.83</td></tr>
<tr><td>Male (M)</td><td colspan="2">25</td><td>47.17</td></tr>
<tr><td colspan="4">Age range</td></tr>
<tr><td>AR</td><td colspan="2">Frequency</td><td>Percent</td></tr>
<tr><td>21 - 25</td><td colspan="2">3</td><td>5.66</td></tr>
<tr><td>26 - 30</td><td colspan="2">12</td><td>22.64</td></tr>
<tr><td>31 - 35</td><td colspan="2">11</td><td>20.75</td></tr>
<tr><td>36 - 40</td><td colspan="2">8</td><td>15.09</td></tr>
<tr><td>41 - 45</td><td colspan="2">10</td><td>18.87</td></tr>
<tr><td>46 - 50</td><td colspan="2">2</td><td>3.77</td></tr>
<tr><td>51 - 55</td><td colspan="2">4</td><td>7.55</td></tr>
<tr><td>56 and above</td><td colspan="2">3</td><td>5.66</td></tr>
<tr><td colspan="4">School location</td></tr>
<tr><td>Rural</td><td colspan="2">Township</td><td>Urban</td></tr>
<tr><td>23</td><td colspan="2">17</td><td>13</td></tr>
<tr><td colspan="4">Age group</td></tr>
<tr><td>Age Group</td><td colspan="2">Frequency</td><td>Percent</td></tr>
<tr><td>21 - 35</td><td colspan="2">26</td><td>49.06</td></tr>
<tr><td>36 - 50</td><td colspan="2">20</td><td>37.74</td></tr>
<tr><td>51+</td><td colspan="2">7</td><td>13.21</td></tr>
<tr><td colspan="4">Teaching experience</td></tr>
<tr><td>1-5</td><td>6-10</td><td>11-20</td><td>21+</td></tr>
<tr><td>19</td><td>12</td><td>15</td><td>7</td></tr>
<tr><td colspan="4">Qualification type</td></tr>
<tr><td colspan="4">BSc/Hons</td></tr>
<tr><td colspan="4">Non-BSc/Hons</td></tr>
<tr><td colspan="4">School quintile</td></tr>
<tr><td colspan="2">1-3</td><td colspan="2">39</td></tr>
<tr><td colspan="2">4-5</td><td colspan="2">14</td></tr>
</table>

Table 4.1 shows the following: A good balance between male and female teachers was achieved. Most teachers came from rural schools, and there was a good balance of teachers who came from township and urban schools. The teachers were divided into five categories related to years of teaching experience, following the guidelines provided by Schneider and Plasman (2011): beginning teachers (1-5 years teaching experience),

mid-career teachers with some experience (6-10 years), and teachers with much experience (11+ years). There are two categories of later-career teachers, namely those with 11-20 years of teaching experience and those with 21+ years of experience. Teachers were further divided into years of teaching experience in Physical Sciences into the categories: beginning teachers in the subject (0 – 5 years), mid-career teachers in the subject (6 – 11 years), late-career teachers in the subject (11 – 29 years) and veteran career teachers in the subject (32 – 33 years). One of the aims of the study is to determine at which age range did the change in beliefs and practices occur, and that's the justification for the further categorisation into young teachers (21 – 35 years), mid-age teachers (36 – 39 years), and old teachers (50 and above years).

Table 4.2 below summarises the interview sample. Only teachers who participated in the survey were eligible to be chosen to participate in the interviews.

Table 4-2: Participants taking part in interviews

Teacher code	Age range	Teaching experience	School quintile	School situated	Qualifications
T1	26 - 30	3 Years	2	Rural	BEd
T51	31 - 35	12 Years	3	Urban	BSc, PGCE
T53	31 - 35	7 Years	1	Rural	BEd Hons, PGCE
T10	26 – 30	3 Years	1	Rural	BEd
T15	31 - 35	3 Years	3	Township	BSc Hons, PGCE
T40	36 - 40	13 Years	5	Urban	BEd
T12	31 – 35	6 Years	2	Township	BEd
T11	31 – 35	2 Years	2	Township	BSc, PGCE
T43	31 - 35	5 Years	3	Rural	BEd Hons
T38	26 - 30	1 Year	1	Rural	PGCE
T25	31 - 35	8 Years	2	Township	BEd
T24	26 - 30	4 Years	2	Township	BSc
T34	36 - 40	15 Years	3	Rural	UDES
T22	51 -55	25 Years	5	Urban	BSc Hons
T4	36 - 40	11 Years	4	Urban	BSc Hons, PGCE
T45	26 - 30	5 Years	2	Rural	PGCE
T23	26 - 30	3 Years	3	Township	PGCE

4.8 DATA MANAGEMENT

At the beginning of the short learning programme, a pre-questionnaire was administered to all 86 teachers enrolled in the programme, to determine the teachers' prior ICT usage, prior ICT skills, prior beliefs, and practices. At the conclusion of the programme, the post-questionnaire was administered to 53 teachers due to the non-attendance of a number of the teachers. For consistency and relevance of the data collected during the pre- and post-questionnaire, data of only the 53 teachers who participated in both the pre- and post-questionnaire were captured and analysed. All responses for the pre- and post-questionnaire were captured in a spreadsheet and submitted to a statistician for analysis.

Seventeen teachers, as described in Table 4.2, were interviewed in stage 5. The interviews were voice recorded and transcribed by me. Interviews lasted for an average of 60 minutes per group. NVivo 12 (QSR International 2012) was used to code the data (see codes used in Appendix 11).

In stage 8, a questionnaire was administered after teachers were interviewed as described above. The purpose of the questionnaire was to validate the findings during the interviews and give teachers another opportunity to express what they could not during the group interviews. All responses were captured in a spreadsheet and submitted to the statistician for analysis.

In stage 9, data collection involved the final assessment. Eighty-seven (87) teachers wrote a compulsory assessment, but only the assessment tasks of the 53 teachers who completed both the pre- and post-questionnaires, were included as data in this study.

The observation was used for the entire duration of the programme. The observation protocol was used as a guide to do observations. Observations were not only limited to the observation protocol but included other observations that could contribute to the purpose of the study. Observation notes were taken during each session. Field notes were further coded using NVivo 12 (QSR International 2012).

4.9 DATA ANALYSIS

To integrate findings and provide a more holistic view to study the phenomena under investigation, different approaches are required by a mixed-methods study at the data analysis stage (Greene, Caracelli, & Graham 1989; Tashakkori & Creswell 2007). The data were analysed in three stages.

The first stage involved the use of both mean and standard deviations, calculated from the pre- and post- Likert scale questionnaire items. This was done to understand the teachers' perceptions before and after the programme, and the changes in perceptions across the professional development opportunity. The descriptive statistics were calculated in terms of participants' responses to items related to perceived usefulness, perceived ease of use, perceived behavioural control, subjective norms, and ICT usage on a five-point Likert scale: 5 – strongly agree, 4 – agree, 3 – neither agree nor disagree 2 – disagree and 1 – strongly disagree (see Appendix 1 & 2). After the presentation of the responses to each statement, participants' choices for both pre- and post-training were summarised by me to determine if there had been any changes in choice for each construct.

After the analysis of teachers' perceptions before and after the training, I used statistical analysis to establish how the teachers' perceptions regarding the use of ICT changed through the course of the professional development opportunity. This was achieved by running a paired t-test, which gave the difference between the pre- and post-questionnaire perceptions and significance value, p = 0.05. When paired t-tests are performed on the same items or participants, they eliminate any variation between samples that may be caused by factors other than that which is being tested. This makes them more powerful than unpaired t-tests (Gleichman 2020). The standard deviations of pre- and post-tests were compared to establish if the difference between the pre- and post-perceptions was significant.

The second stage involved the use of analysis of covariance (ANCOVA) of the pre-post differences regarding biographical factors, where the p-value = 0.05. Field (2009, p. 781) describes the analysis of covariance as "a statistical procedure that uses the F-ratio to test the overall fit for linear model controlling for the effect of one or more covariates have on the outcome variable".

The third stage involved the use of NVivo 12 to code qualitative data gathered from the semi-structured interviews and observations. This data would assist in showing how the teachers' perceptions changed through the course of the professional development programme, and how school factors affected the change in the use of ICT. It would also assist to determine teachers' perceptions regarding the change in the quality of teaching and learning when ICT was used, the practices displayed by teachers when they used technology at the end of the professional development opportunity, and to identify the issues that arose during the professional development, as well as the teachers' responses to these (see Appendix 11). I further grouped data into themes to respond to research questions 2, 4 and 5.

4.10 INTEGRITY OF THE STUDY

The quality of inferences generated from a mixed methods study are directly influenced by quality of the respective qualitative and quantitative results. Therefore, it is of critical importance to evaluate the results in the qualitative and quantitative study strands by using common quality standards adopted in quantitative and quantitative research (Creswell & Plano Clark 2011; Greene 2007; Teddlie & Tashakkori 2009).

The methodological quality of quantitative data is assessed based on their validity and reliability using statistical procedures. In qualitative research, the methodological quality of the data is assessed by determining "whether the findings are correct from the perspective of the researcher, the participant, or the readers" (Creswell 2014, p. 201). In other words, researchers are interested in the credibility and trustworthiness of the qualitative findings and their interpretations.

4.10.1 Validity and reliability of quantitative data

The data is valid when the study instrument measures what it is supposed to measure. The research study is considered entirely genuine if there is no mistake in measurement (Surbi 2017). The main types of validity applicable in this study are construct and content validity.

4.10.1.1 Content validity

The point at which the instrument provides acceptable coverage of the subject under investigation is called content validity (Surbi 2017). In this study the pre- and post-questionnaire design was based on the construct of the theories being measured, thereby providing adequate coverage of what was tested. The concept of acceptance was used to align with the constructs of theory of planned behaviour and technology acceptance model, therefore grounding the questionnaire in these theories, as explained in Chapter 3 The questions from the questionnaire were further classified according to the constructs of theory of planned behaviour and technology acceptance model

Construct validity refers to the point at which inferences regarding test scores relating to the concept under study can be made. Is it true, for example, that a high score on an ICT usage survey indicate that the person has a high proficiency level of ICT usage? Evidence for construct validity can be gathered by showing that the instrument measures a single underlying construct, and that the result of the test instrument is aligned with the theoretical assumptions of the construct. Teachers with favourable ICT beliefs, for example, are more inclined to use technology to meet their pedagogical requirements. Furthermore, they are likely to expand their abilities in order to improve their efficacy and efficiency. On the other hand, technology integration is seen as an add-on activity by teachers with negative ICT beliefs. As a result, many do not incorporate ICT because they fear it will add to their already heavy teaching loads (Mbatha 2015).

4.10.1.2 Reliability

Reliability refers to the degree to which an instrument consistently gives the same results when employed in similar settings. When a person completes a questionnaire that assesses their beliefs, they should have roughly the same results each time the questionnaire is completed. The internal consistency and equivalence of an instrument can be used to determine its dependability (Heale & Twycross 2015).

Internal consistency is commonly determined by using Cronbach's coefficient alpha. The average of all correlations in each combination of split-halves is determined in this test. It is employed in instruments that have questions with more than two answers (Heale & Twycross 2015). The Cronbach's coefficient alpha result is a number between 0 and 1. According to Lobiondo-Wood and Haber (2013), an acceptable reliability score is 0.7 or higher, as outlined in Table 4.3 below.

Table 4-3: Cronbach's coefficient alpha reliability values (Lobiondo-Wood & Haber 2013)

Cronbach's coefficient alpha value	Reliability
Greater than 0.90	Very high reliability
0.80 – 0.90	Highly reliable
0.70 – 0.79	Reliable
0.60 – 0.69	Marginally reliable
Less than 0.60	Unacceptable low reliability

The study used a quantitative inferential pre- and post-design questionnaire to measure the change in ICT beliefs, change in ICT usage, and how age, gender, qualifications, and school environment affected the change in the use and beliefs of ICT. The Cronbach coefficient alpha reliability results for different category of questions are shown in Table 4.4 below.

Table 4-4: Cronbach's coefficient alpha reliability results

Type of a questionnaire	Cronbach's coefficient alpha		Reliability
	Raw	Standardised	
Perceived usefulness of pre- and post-questionnaire	0.879102	0.89102	Highly reliable
Perceived ease of use for pre- and post-questionnaire	0.738530	0.736194	Reliable
Usage for pre- and post-questionnaire	0.815225	0.809675	Highly reliable
Perceived behavioural control for pre- and post-questionnaire	0.846743	0.846784	Highly reliable
Subjective norms for pre- and post-questionnaire	0.843499	0.842151	Highly reliable

As seen in Table 4.4, Cronbach's coefficient alpha values for perceived usefulness, usage, perceived behavioural control, and subjective norms reveal a high reliability score for pre- and post-questions. On the other hand, the Cronbach's coefficient alpha value for perceived ease of use reveals a reliable score for pre- and post-questionnaire. Therefore, the Cronbach's coefficient alpha values in Table 4.4 assume that the pre- and post-questionnaires in this study were internally reliable.

4.10.2 The trustworthiness of qualitative data

Trustworthiness is a concept introduced by Lincoln (1995) and Guba (1981) to represent many of the quality measurements in qualitative research. Transferability, credibility, dependability, and confirmability are four criteria identified by the authors for the trustworthiness of qualitative data.

4.10.2.1 Transferability

The transferability of research findings to various contexts is defined as the extent to which the findings revealed in one study are applicable to subsequent research (Houghton, Casey, Shaw & Murphy 2013; Polit & Beck 2012). Qualitative research studies are not generalisable by quantitative standards, since findings in qualitative research frequently relate to a small number of locations or individuals (Flyvbjerg 2006). As a result, when compared to quantitative studies, the number of research participants is frequently lower, and the exhaustive character of each case becomes more essential than the number of participants (Polkinghorne 2005).

It is difficult to show that qualitative study conclusions or findings may be applied to different contexts or groups (Drury, Homewood & Randall 2011). Instead, the goal could be to find and begin to explain phenomena that have not yet been properly defined due to a lack of clarity. The phenomenon will often appear unusual, necessitating inquiry for researchers to establish hypotheses about it or comprehend the various views that define it (Denzin & Lincoln 2011). The likelihood of the teachers in this study being a representative sample of other South African teachers is enhanced by the wide range of biographical characteristics of the sample (see Table 4.1). Additionally, rich descriptions of the observations made during this study are provided in Chapters 5 and 6, to aid the reader to form naturalistic generalisations.

4.10.2.2 Credibility

Credibility refers to the accuracy of the participants' views or data, as well as the researcher's representation and interpretation of it (Polit & Beck 2012). To establish rigour in an inquiry, a qualitative researcher adopts credibility approaches such as method and data triangulation. A number of data sources and methods are therefore used (Padgett 2008). This study used different data collection methods, both quantitative (questionnaires) and qualitative (interviews) data collection tools, and multiple data sources (questionnaire responses, interview transcripts, observation field notes, and the final assessment rubric). Data were also collected at different points in time to ensure that deductions were not based on once-off events.

The same data, for example questionnaire responses, were also analysed using different methods such as descriptive data presentation and statistical analysis to triangulate findings. Shenton (2004) indicates that credibility is strengthened when participants have the freedom to participate or not. Teachers were invited to participate but could still decide whether to take part or not. Many teachers participated in the questionnaires and semi-structured interviews. During the interviews, I aimed to build rapport with the participants by emphasising that there were no correct or incorrect responses and that they were participants in this study rather than "experiment subjects."

4.10.2.3 Dependability

Dependability refers to the consistency and reliability of the research findings, as well as to the level to which research techniques are documented to allow an external person to review, audit, and follow the same research process (Polit & Beck 2006; Streubert 2007). Examining extensive coverage of the approach and procedures used, allows the reader to determine the extent to which suitable research practices have been followed (Shenton 2004). Lincoln and Guba (1985) argue that for data to be valid, it should be reliable. In the same way, for data to be credible it should be dependable. A demonstration of credibility should be enough to establish dependability. A full description of the research design and implementation was provided in this study, which included methodology and methods (as explained in section 4.5), data gathering (as explained in section 4.2), and sample selection (as explained in section 4.6). The design and data collection tools were included, as well as detailed descriptions of the various coding schemes and data analysis techniques.

4.10.2.4 Confirmability

Confirmability refers to the researcher's ability to show that the data reflect the participants' responses rather than the researcher's prejudices or perspectives (Polit & Beck 2012). As discussed previously, multiple methods of data collection and sources of data, as well as triangulation of data analysis approaches, were employed to reduce researcher bias and ensure that the findings and deductions emerged from the data and not from the researcher. For example, rich quotes from the participants that depicted themes during data analysis were included.

4.11 ETHICAL CONSIDERATIONS

I attended to several ethical considerations.

4.11.1 Seeking permission from authorities

I sought permission from the concerned authorities before conducting this research, including approval of the research project by an academic institution, and permission from the education authority where I would conduct research. As such the following steps were taken:

- As a first step towards ethical clearance, the research proposal was presented within the special interest group, and then the proposed title was registered at the Faculty of Education at the University of the Free State.

- Ethical approval was received with the number UFS-HSD 2017/1134. This included approval for all internal gatekeepers, and permission for the study was granted by the department and the Short Learning Programme Unit.

- I applied for permission at the Free State Department of Education

- The following declarations are made:

    - The facilitator of the programme is also my study supervisor. The supervisor is employed by the University of the Free State, which is remunerated to run this programme.

    - I am employed by the Department of Education, which applied to the SETA to fund this programme.

    - The co-supervisor is not related to the programme in any way.

    - I do not have any influence on the current programme

    - I am an observer in the programme. My presence and role during the programme were made known to the participants.

  - To ensure validity for every coding category, which suggests effectiveness, I created a rebutting coding category and explicitly searched the data for both confirmatory and contradictory evidence. The same was done for every coding category generated to suggest ineffectiveness.

4.11.2 Respect for human dignity

This is the core ethical principle that underpins research ethics, and it is designed to safeguard an individual's physical, psychological, or cultural integrity (Harriss, MacSween & Atkinson (2020). As such, I undertook and have treated the participants with respect. I protected individual integrity and preserved individual freedom when I was observing during sessions, during interview sessions, and when I presented and analysed data.

4.11.3 Informed consent

Informed consent: After a participant has been informed of the research risks, procedures and so forth, he or she gives permission to be part of the research project. The following steps were taken in this regard (Bhandari 2021):

- There was openness through the process of the research. Participants were informed of my presence during the short learning programme sessions, for example.

- I took all necessary precautions to ensure that all research participants were aware of the research process, including why their participation was required, how it would be used, and how and to whom it would be reported.

4.11.4 Freedom to withdraw

Freedom to withdraw: In this case, participants were notified that they were free to withdraw from the study project at any time, without any penalty or loss of rewards (British Educational Research Association 2018). I, therefore:

- informed them about their right, for any reason and any time, to withdraw from the study without any penalty imposed on them. It was also made clear that they would not lose any benefits, such as the “7” inch tablet they were entitled to.

- informed them that any information collected would not be used in the research.
- informed them that they could withdraw verbally, or by failure to further participate.

4.11.5 Confidentiality

Everyone has the right to restrict other people's access to information about their person. Respect for the individual is very important, because personal data can be used in the wrong way. Even in the absence of such misuse, it can be both harmful and disagreeable if sensitive information goes astray (Fossheim 2015). Therefore,

- I kept the information from the respondents strictly secret. No information was disclosed in any of the records, and there was no reporting on the personal data of the respondents without the consent of the respondents.
- I acknowledged the private rights of participants and granted them these rights.
- I ensured that participants' information was not shared in any way that could identify them.

4.12 CONCLUSION

The research design for the study consisted of a sequential mixed methods design, which used survey and case study approaches. Followed by a series of qualitative analysis methodologies, a quantitative data analysis provided insight into how the perception of teachers about the use of ICT may be modified by a subject-specific professional development opportunity.

The study was divided into ten stages. Stages move from instrument selection and design, to data collection using the designed data collection instruments. Several different measures were put in place to ensure high-quality data collection and analysis for this study. These measures informed the entire study, including the choice of methodology and research methods, the design of data collection tools, the sampling choices, and the data analysis procedures. In the next chapter, a detailed description of the course is provided.

CHAPTER 5: DESCRIPTION OF THE CASE

5.1 INTRODUCTION

The purpose of this chapter is to provide a rich description of the case under study in order to provide the reader with insight to be able to make judgements about the validity (Plowright, 2011) of the claims made in the following chapter, in which the answers to the research questions are presented. The short learning programme is first described, after which an attempt is made to paint a picture of the range of experiences that teachers had across the duration of the short learning programme.

5.2 THE SHORT LEARNING PROGRAMME

5.2.1 Background

The short learning programme that serves as a case for this study was aimed at enhancing the effectiveness of the teaching and learning of Physical Sciences in the Free State province of South Africa, by strengthening teachers' content knowledge and promoting teacher ICT usage. The programme was an initiative of the Department of Education in the Free State in partnership with the University of the Free State in Bloemfontein and funded by the Education Training and Development Practices Sector Education and Training Authority. The original target was to enrol 100 Grade 10 in-service Physical Sciences teachers from three districts in the province, namely Motheo, Xhariep, and Lejweleputswa, although this target was not met since only 86 teachers enrolled.

The logistics, specifically regarding funding timelines, meant that the relevant staff members at the University of the Free State were given a little over a month to conceptualise and create the short learning programme, as well as to register the participants and meet all the administrative requirements of the funder Education Training and Development Practices Sector Education and Training Authority, the Department of Education, and the University. The staff consisted of three qualified science teachers: (1) a full-time administrator who was responsible for administration and also for setting the content tests; (2) a project leader who was involved in multiple other projects at the same time, and who was responsible for co-ordinating the various aspects of the programme and communicating with the various bodies and people involved; and (3) the facilitator who also created the short learning programme. This person was occupied in another position from Monday to Thursday each week.

The short learning programme was advertised on social media and communication platforms used by the Free State Physical Sciences subject advisers. Attendance was free, and all participants would receive a tablet and Physical Sciences software on registration. Registration was voluntary and on a first come first served basis. Eighty-six teachers registered, although six teachers did not finish the programme. The teachers were given pre- and post-questionnaires, for the purpose of this research, to complete at the first and final sessions, respectively. Fifty-three teachers completed both of these questionnaires, and 17 of these also participated in focus group interviews in the last session. This data, together with the administrative records and the resources used in the short learning programme, were used to generate the descriptions given in this chapter.

5.2.2 Aims and resources

Guzman and Nussbaum (2009) argue that effective training in technology integration will only take place if a set of professional competencies are targeted. This programme mainly focused on instrumental or technological, pedagogical or curricular, and didactic or methodological competencies (as explained in sections 2.10.4.1-2.10.4.6). The programme was grounded in promoting the TPACK framework (cf. 3.11). According to Herring, Koehler and Mishra (2016), training grounded on TPACK principles is a requirement for ICT to be effectively used in education. The key to better ICT use is to provide teachers with the skills and know-how to move beyond the use of ICT to replace conventional ways of teaching (Almerich et al. 2016; George & Sanders 2017). In a study by Kabakci Yurdakul and Çoklar (2014), it was found that ICT training grounded in TPACK improved Turkish teachers' ICT-usage.

The resources supplied to the teachers were designed to develop the teachers' pedagogical, content and technological and knowledge for teaching Physical Sciences. In addition to a Samsung 7" tablet, the teachers each received resources which firstly targeted technological knowledge. Short technological demonstration movies, downloaded from YouTube, were saved in relevant folders on the micro-SD card that each teacher received. Examples include demonstrations of basic and more advanced use of PowerPoint, ZipGrade, Kahoot and Plickers. Additionally, the teachers were given printed instructions (click here for the online version of these) on how to navigate the folder system on the micro-SD card in order to access these movies. They also received resources focused on pedagogical knowledge. The presentations used by the facilitator to teach the various pedagogies targeted in the short learning programme were saved onto the micro-SD card. These presentations can be accessed through the links given in Table 5-1. Additionally, practitioner-directed articles relevant to each of the pedagogies covered in the short learning programme, were loaded onto the teachers' micro-SD cards. Thirdly, they received resources on content knowledge. By the end of the short learning programme, each teacher had the full 9Gb offline Grade 10 Physical Sciences software package, created by Dr Angela Stott, saved onto their micro-SD cards. This software includes teaching videos (for examples click here), PowerPoint presentations, worksheets, and interactive electronic quizzes. Research related to the use of these quizzes in the South African context has been the subject of a number of publications (Stott 2018a, 2020a, 2020b; Stott & Beelders 2019). They were given a license to load this software on every device at their school for use by all their learners, and they were encouraged to do this for the duration of the short learning programme. The teachers were also encouraged to bring tablets from their schools to the contact sessions to get technical assistance from the facilitator in how to install the software onto these devices. In addition, the teachers were given printed versions of the content task instructions, which can be accessed using the hyperlinks in Table 5-1. These instructed the teachers which tasks they needed to work through, using the software, as the minimum homework requirement between sessions. Besides the 9Gb offline Grade 10 Physical Sciences software package, the resources were provided electronically both offline, on each teacher's micro-SD card, and online, at bit.ly/gr10psslp. In addition, the teachers were given many of the resources in hard copy.

Given the short amount of time available for preparation of the course, some of the content of the course had to be developed during the course. Although the participants were given a plan and some resources at the start of the course, they were also given resources at the start of each session. Additionally, the Physical Sciences software package software had been created for use on a computer, and conversion to a format compatible with android tablets had not yet been completed by the start of the course.

This meant that the teachers could only be given some of the software at the start of the course, with additional material being provided later in a series of electronic patches. The initial plan was that this patching should be done by each teacher during the session, through access to Google Drive, where the latest patch would be stored. Teachers were given guest passwords for the university Wi-Fi at the beginning of workshop to access this patch, as well as to access Blackboard for writing tests electronically at the end of the session. However, unanticipated problems arose, partly due to the less intuitive procedure for applying a patch on a tablet, relative to a computer, and the less intuitive mobile app for Blackboard, relative to the computer-based version, and mainly due to poor and variable Wi-Fi quality at the university. Consequently, after a few sessions, paper-based tests were used instead of electronic tests, and the facilitator applied the patches to the participants' tablets via cable during the session. It appeared to me, however, that many of the teachers developed negative attitudes of frustration due to the initial difficulties they experienced with the Wi-Fi, the patches and the online tests on Blackboard, and that some might not have recovered from these negative attitudes despite the later measures put in place to mitigate them.

5.2.3 Structure, timeline, and assessment of the programme

Rudduck (1986) found that short-duration (four hours or shorter) teacher education workshops did not have a meaningful effect on the teachers' subject matter knowledge. Although this view was disputed by Stott and Case (2014), who provided evidence for some subject matter knowledge gain among South African Physical Sciences teachers following such a short-duration workshop, it is generally understood that programmes for in-service teacher education of a longer duration are superior, particularly when ICT uptake is targeted (Cradler, Freeman, Cradler & McNabb 2002). The short learning programme was relatively extensive. A blended approach was used, with 70 hours of contact time and at least 80 hours of distance engagement being expected of the teachers. The contact time usage is summarised in Table 5-1. Between these contact sessions, the teachers were expected to engage with the provided software and implement their learning in the classrooms for the final assessment task, as described below.

As shown in Table 5-1, the short learning programme consisted of a 2-hour information session, followed by two 8-hour technical sessions at the start of the short learning programme, and thirteen 4-hour sessions which alternated between a focus on pedagogy and content. In addition to these planned sessions, which took a total of 70 hours, a 7-hour catch-up session was provided in the winter holidays to cater for teachers who fell behind due to absenteeism. The technical and pedagogical sessions were indicated as being compulsory for all, although there was a great deal of absenteeism. The teachers wrote a content test on the subject at the end of each pedagogy session (as seen in Table 5-1). They had been expected to work through the homework related to this topic after each session, using their tablet and the offline Grade 10 Physical Sciences software package. Those teachers who scored 80% or higher in this test were not compelled to attend the next session, which focused on the content of that topic. At the end of each content session, the teachers who attended wrote a second test on the same topic. The contact sessions indicated in Table 5-1 took place over the weekend. Except for the whole-day technical sessions, attended by all the teachers simultaneously, each programme item was offered twice, and teachers could choose which of the two sessions was more convenient for them to attend- either Fridays 14:00: – 18:00 or Saturdays 9:00 - 13:30.

Due to the rushed start of the programme to meet the timeline imposed by the funders, the tablets were not available by the time of the first technical session. Consequently, a computer-based technical session was designed as a fill-in. By the time of the second technical session the tablets had arrived. Unfortunately, however, the limitations imposed by the poor and variable campus Wi-Fi were only discovered during this session, and this resulted in frustration and confusion as the planned outcomes could not be met. Additionally, a prominent sports match was played on that day, resulting in most of the teachers leaving early. Additionally, many teachers tended to work very slowly, partly due to poor technological skills and partly due to difficulties with the Wi-Fi. Consequently, the targeted technical outcomes in the use of a tablet and the use of the provided software were not met by most of the teachers, with obvious negative consequences for the rest of the short learning programme.

The completion of the course was incentivised by the participants being allowed to keep the tablet as well as the potential of earning credits towards various qualifications, through a process of recognition of prior learning (RPL). To pass the course, the participants had to achieve 50% or higher for the course. The course mark was obtained from two equally weighted components: (1) Content test mark, obtained from the average of the four highest marks the participant scored in tests across the six topics, where a maximum of 11 tests may have been written. (2) A final assessment task (click here to view the task instructions, template and rubric used), in which each participant was required to implement any two of the pedagogies covered in the pedagogy sessions in their class, and document and reflect on this process.

Table 5-1 *The structure of the short learning programme, with hyperlinks to some of the resources used. Technical sessions are shaded pink and pedagogical sessions blue.*

Date, duration venue	Homework done by this date	Presentation	Activity	Compulsory for	Test in the last 30 minutes
18/02; 2 hours; South campus		Introduction	Registration and debriefing	Everyone	
25/02; 8 hours; Main campus computer centre			Computer tasks	Everyone	
04/03; 8 hours; South campus		Files and folders apps	Tablet tasks	Everyone	
10,11/02; 4 hours; South campus	Matter and materials tasks	Algorithms and heuristics	Start of Inquiry: Practical demonstrations (slide 1).	Everyone	Matter and materials
25/03; 4 hours; South campus	Matter and materials tasks		Matter and materials tasks	Those who achieved below 80% for the Matter and materials test	Matter and materials rewrite
5,6/03; 4 hours; South campus	Waves content tasks	Remembering and forgetting	Competition between groups	Everyone	Waves
12,13/05; 4 hours; South campus	Waves content tasks	Tablet and cell-phone installation	Waves content tasks	Those who achieved below 80% for Waves test	Waves rewrite
19,20/05; 4 hours; Main campus computer	Electricity and magnetism tasks	Inquiry	Inquiry	Everyone	Electricity and magnetism

centre					
2,3/06; 4 hours; South campus:	Electricity and magnetism tasks		Electricity and magnetism tasks	Those who achieved below 80% for Electricity and magnetism test	Electricity and magnetism rewrite
9,10/06 4 hours; South campus:	Chemical change tasks	Conceptual teaching	Conceptual teaching	Everyone	Chemical change
23,24/06 4 hours; South campus:	Chemical change tasks		Chemical change content	Those who achieved below 80% for Chemical change test	Chemical change rewrite
4,5/07 7 hours; South campus	• Matter & materials tasks • Waves tasks • Electricity and magnetism tasks • Chemical change tasks		Catch-up sessions run informally on-demand	Those who have not written the required tests yet	
11,12/08 4 hours; Main campus computer centre	• Mechanics tasks • PowerPoint task • Final assessment task: First drafts / plans		• Presentation principles • Final assessment task share and help	Everyone	Mechanics
25,26/08 4 hours; South campus:	• Mechanics tasks		Mechanics content	Those who achieved below 80% for Mechanics test	Mechanics rewrite
8,9/09 4 hours; South campus:	• Hydrosphere tasks		• Problem-solving	Everyone	Hydros-phere
15,16/09 4 hours South campus: D100/D206	Final assessment task: second draft		Apps & sites; Games	Everyone	

22,23/09 4 hours Main campus computer center	Final assessment task: final		• Final assessment task: submit and showcase • Pair and share • Upload to submit	Everyone	

5.2.4 *Context and philosophy of the programme*

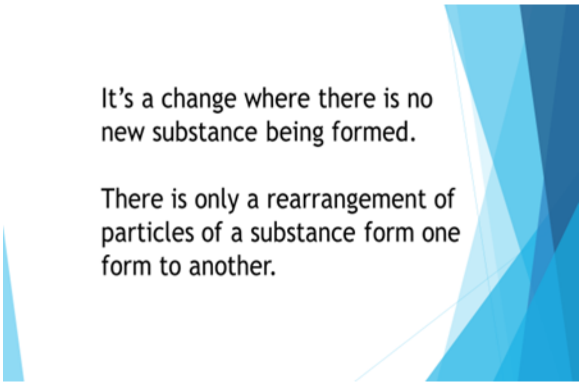
Each of the pedagogy session started with an approximately 1-hour presentation by the facilitator. The topics of these presentations are given in Table 5-1, from which the hyperlinked PowerPoints can be accessed. During these presentations, the facilitator presented relevant practitioner-directed pedagogical theories, and applied these to practical Physical Sciences teaching examples. After this, the teachers engaged in tasks in which they applied what had been presented within the context of using ICT in teaching Physical Sciences. These activities are accessible from the hyperlinks in Table 5-1.

For example, for the session focusing on presentation pedagogy on the 11th and 12th of August, the teachers were asked to bring along a PowerPoint presentation to the session, although fewer than half followed this instruction. The facilitator presented Mayer's Presentation Principles (Mayer's 2009), embedded in the Information Processing Model of Learning. This presentation was meant to take an hour, but due to poor attendee punctuality the facilitator considered it inappropriate to start until half an hour into the session, and even so many of the teachers did not arrive until the presentation was almost finished. For each of the presented principles, the facilitator displayed slides showing examples of poor use of PowerPoint, asked the participants to critique these, and then showed examples of improved versions of each slide. This presentation, as well as the task instructions, can be accessed by clicking here. The teachers were then expected to apply the demonstrated principles to improve their own PowerPoint presentations for the next hour and a half. Those who had not brought PowerPoint presentations were helped to create one. In the last half hour before the content test was written, a few teachers volunteered to present their 'before' and 'after' slide versions to the class, and to explain how they had applied the Presentation

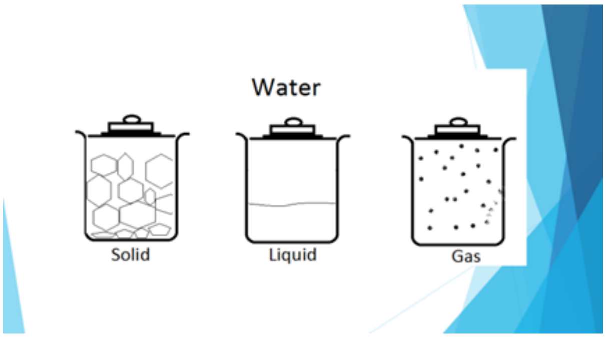
Principles in making certain changes. Since there was a wide range of PowerPoint technical skill among the teachers, the outcomes they achieved differed widely - from merely opening the application and typing a few words, to making significant improvements to an existing PowerPoint, in line with Mayer's (2009) Presentation Principles.

Figures 5.1 and 5.2 present examples of one teacher's PowerPoint task before and after exposure to the session on principles of good presentation. Changes include an increased use of images and decreased use of text.

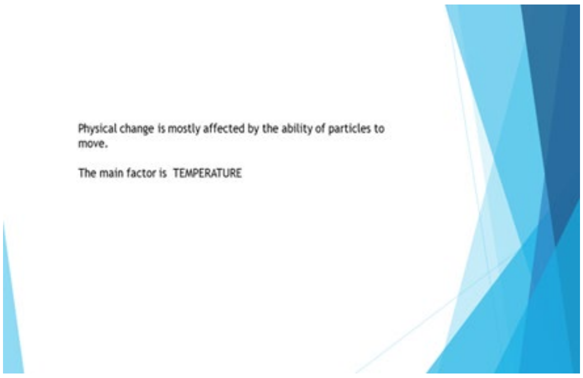
Slide 1



Slide 2



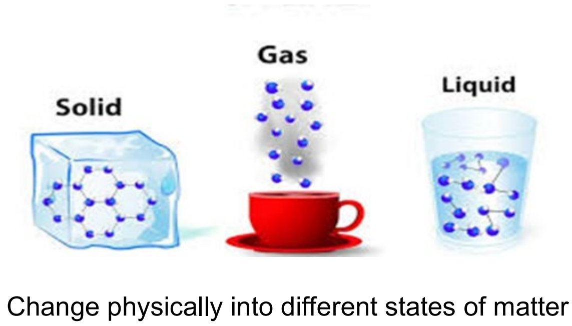
Slide 3



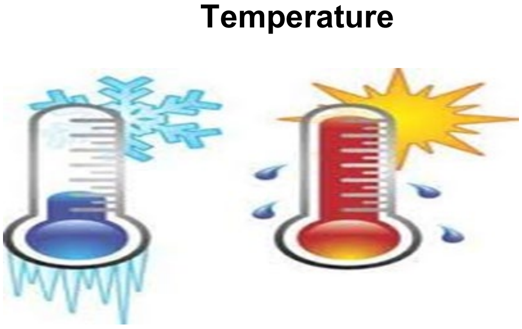
Slide 4

Figure 5-1: PowerPoint presentation of a teacher before the session on Presentation Principles

Slide 1



Slide 2



Slide 3

Figure 5-2: PowerPoint presentation of a teacher after the session on Presentation Principles

5.2.5 Communication

The short learning programme had four forms of communication, namely the website bit.ly/gr10psslp, a WhatsApp group, email, and Google Classroom. The website was created by the facilitator, and it contained all of the content including the pedagogies to be taught, presentations per topic, tasks and their instructions, a detailed programme, calendar, and assessment information. The website allowed teachers to download all the presentations and any other information they needed.

The WhatsApp group allowed teachers to communicate with the facilitator the challenges that they experienced, and share their experiences, including photographs, as they implemented their learning from the programme in their classrooms. These posts likely helped to motivate other teachers to also implement their learning in their classrooms.

Notices and any other information were communicated through email, and Google Classroom was used to submit the final assessment tasks.

5.3 THE TEACHERS' EXPERIENCES WITH THE SLP

The aim of this section is to immerse the reader in the experiences that the teachers had with the short learning programme. This is done to provide the reader with information they can use to judge the validity of claims made when answering the research questions in Chapter 6. To reach this aim, the range of teaching contexts in which the teachers taught is briefly referred to as a backdrop for the rich descriptions which follow. To contextualise the few examples which are elaborated on, the sample is divided into three categories based on the teachers' technological skill at the start of the SLP. For each category, comparisons are made between the given example and the group as a whole, to give the reader an understanding of the ways in which the example is similar and different to other members of the group.

5.3.1 Biographical contexts of the teachers

Lucking, Bligh, Munches, Ainsworth, Crook and Noss (2012) argue that the context of the school in which digital technologies are used is critically important for the success of teachers in using digital technologies. Fullan and Langworthy (2013) agree that the context of a school should be considered when trying to understand teachers' experience with technology. This applies to understanding the teachers' experience with this short learning programme, too.

Table 4-1 gives detailed biographical descriptions of the 53 participants who completed the pre- and post-questionnaires. Of these, 39 taught at quintile 1 to 3 schools, which serve the approximately 75% of South African learners who live in poor communities. Such schools usually underperform (Spaull, 2013). Fourteen teachers came from quintile 4 to 5 schools, which serve more affluent communities. Twenty-three teachers taught in rural schools, 17 teachers in townships and 13 in urban areas[2].

5.3.2 Initial technological skills of the participants

Consistent with Jacobs' survey (2018) of computer literacy among teachers in the Free State province, there was a broad spectrum of ICT competence among the educators. Clarkson and Oliver (2002) identify four phases that teachers pass through in their progress towards integrating ICT in their classrooms. These phases are dependence, counter-dependence, independence, and interdependence. I added a phase 'non-usage' to describe the phase before teachers begin using ICT in teaching. As teachers progress along these phases, they develop increasing technical competence and confidence with ICT usage, and this enables them to devote increasing time and energy to the development of pedagogical knowledge. It should be noted that the questionnaires did not measure the degree of learner- or teacher- directedness in the teachers' pedagogy, so it was not possible to differentiate between the counter-, in-, and inter-dependence phases based on the questionnaires. However, it is known that teachers in developing countries, including South Africa, tend to teach in a teacher-directed manner (Schweisfurth, 2013). Therefore, only the phase I added (non-usage), and the lower two phases (dependence and counter-dependence) were used as category names to describe the level of ICT integration with which the teachers started the SLP, as presented in Table 5-2. It seems reasonable to expect that a teacher should progress from their starting phase to the next phase, at least, within the course of an intervention such as this SLP.

2 In the South African context, "township" refers to high population density areas that, under apartheid, were exclusively reserved for people of colour. "Urban areas" are suburbs that were in the past reserved for white people, and still have better infrastructure. "Rural" refers to low population density areas, as well as to areas that are geographically remote from economic opportunities and amenities (Fish, Allie, Pelaez & Anderson, 2017).

***Table 5-2** Categorisation of teachers in the sample regarding the initial phase of ICT integration into teaching*

Mean for ICT usage category of pre-questionnaires (/5)	Deduced phase of initial ICT integration into teaching	Meaning of this phase (Clarkson & Oliver 2002)	Number of teachers in sample (/53)
1 - 3	Non-usage	Not integrating ICT into teaching	21
4	Dependence	Focus is on technological skills rather than pedagogy	22
5	Counter-dependence	ICT is integrated into lessons in a teacher-directed manner	10

5.3.3 Experience of teachers who started the SLP within the non-usage phase

5.3.3.1 The teachers in the non-usage phase category

Table 5-3 below gives some biographical details of the teachers who were classified in this category. This group is relatively old, with only one teacher (T38) being younger than 35, and with six older than 50. The group covers the full spectrum of the South African teaching context regarding school location and quintile. Apart from T38, who said that his school had only one computer used by the clerk for administrative purposes *(Interview, T38, 22/09/2017)*, the teachers said that their schools had several computers. Of these 21 teachers, three participated in the interviews, and of these three I chose T33 as the example to describe in detail for this section, since she was the most articulate about her experience of the short learning programme.

Table 5-3: Teachers classified as starting the SLP in the non-usage phase of ICT usage

Teacher code	Age range	Teaching experience	School quintile	School situated	Qualifications
T22	51 -55	25 Years	5	Urban	BSc Hons
T34	36 - 40	15 Years	3	Rural	UDES
T38	26 - 30	1 Year	1	Rural	PGCE
T39	41 - 45	20 Years	2	Rural	UDES
T47	56 and above	32 Years	4	Urban	BSc
T50	36 - 40	14 Years	1	Township	UDES
T5	41 - 45	21 Years	3	Township	BEd Hons
T19	56 and above	31 Years	5	Urban	HDE
T33	51 - 55	18 Years	1	Rural	UDES

T2	36 - 40	9 Years	3	Rural	BSc
T6	41 - 45	15 Years	1	Rural	ACE
T7	41 - 45	2 Years	1	Rural	PGCE
T8	41 - 45	17 Years	3	Rural	BEd Hons
T18	41 - 45	16 Years	2	Rural	BEd Hons
T19	56 and above	31 Years	5	Urban	HDE
T20	41 - 45	13 Years	3	Township	BEd Hons
T31	41 - 45	13 Years	3	Rural	PGCE
T35	36 - 40	14 Years	1	Rural	HDE
T36	56 and above	40 Years	5	Urban	BSc Hons
T37	36 - 40	10 Years	1	Rural	NPDE
T52	41 - 45	17 Years	1	Rural	HDE

5.3.3.2 The experience of one of these teachers during the course of the SLP

T22 teaches at an independent school. These are schools that are under the governance of an independent board of trustees and funded by external organisations such as religious groups, unlike public schools which are 100% fully funded by the Department of Basic Education. Such schools are characterised by lower learner numbers and more facilities and advanced technology, compared to public schools (Kennedy 2020). During the interviews at the end of the short learning programme (23/09/17), T22 reported that she started the short learning programme knowing very little about ICTs. She said that this often made her feel frustrated and lost during the short learning programme. At the start of the following extract from her interview on 23/09/17, she seemed to be saying that sometimes she would want to complete a task, but instead the instructor indicated that the group should move on to the next activity. This suggests that she found the pace of the SLP too fast, and possibly the expectations too disjointed. At the end of this extract, it seems as if she is implying that the SLP was very intense, since she needed a break from it. It is unclear what the ‘lots of talking’ she mentions refers to. It is possible that it could have been the facilitator’s presentation, or the participant discussions during the activities. It certainly seems clear from this extract that she experienced a high degree of cognitive load in the SLP.

> *“I don't know, I was lots of times very frustrated because I wanted to finish this job and then it is already three hours and please leave this one, go there. It made me*

> *angry, frustrated. Then I had a week to think about it, and taking a break, a break is not for eating. A break is a break because a human being needs a break after two hours of a lot of talking (Interview, T22, 23/09/17).*

Despite this cognitive load and the expression of frustration, anger and difficulty, the two assessment tasks she submitted at the end of the short learning programme demonstrated considerable technological knowledge and PCK, as described below. This corresponds to her statement in the interview that “I did not like it at all, but I learned a lot. I worked through that lot of things, and I did it” (Interview, T22, 23/09/17).

For the two lessons implemented, documented and described in the final assessment task, T22 chose the pedagogies Presentation and Conceptual teaching from those covered in the SLP (See Table 5-1). The ICT she used were PowerPoint, ShareIt and video. These were used and reflected on in the task with a high degree of pedagogical insight. For example, she used the PowerPoint, which she created for, and refined after, the Presentation Principles session on 12/08, to interactively develop learners’ ability to name compounds such as potassium dichromate and potassium permanganate, from building the names up from the component ions. She did this by first drilling the learners in knowledge about compound ion names and formulae, applying the principles covered in the “Remembering and forgetting” module of the short learning programme on 06/03, after which she asked learners to apply this drilled knowledge to name compounds she provided in her presentation. She reported, in her final assessment reflection essay, that after she had engaged interactively with the learners in this manner with several examples, the learners spontaneously started challenging one another to name compounds that they proposed themselves.

In the conceptual teaching task, T22 began the lesson with a problem related to an electric generator, and ended the lesson with a self-study task related to the photoelectric effect. Although the first part of the lesson did not utilise ICT, it demonstrated the principles of conceptual teaching covered in the session on 10/06. She had a model of an electric generator, from which she had removed the brushes. She asked the learners to explain why the model would not generate electricity, what to do to fix it, and why this would work. In the last part of her lesson, she used ShareIt to send videos about the photoelectric effect to each learner’s cell phone. She had used Google to find these videos on YouTube and download them onto her tablet. She divided the topic into sections, assigning one to each group of learners, and she instructed each group to watch the video, focusing on their assigned topic, and prepare a presentation for the class on this topic for a later lesson.

This description demonstrates that T22 was able to use several ICT resources (PowerPoint, Google, Shareit, and YouTube) by the end of the short learning programme, despite having reported both in her pre-questionnaire and in her interview, that she had had little prior exposure to ICTs before the short learning programme. Further, we see that the ways she applied these ICTs were pedagogically meaningful. For example, using PowerPoint, she first promoted learner competence and confidence through drill, followed by promoting classroom interaction through the dialogue she conducted with her learners. Her self-reflection essay, submitted at the end of the short learning programme, demonstrated that she used this interaction to diagnose learners' conceptual difficulties. She further used it to adjust her teaching in a manner appropriate to remedying these difficulties, corresponding to Chan, Rollnick and Gess-Newsome's (2019) components of PCK, namely knowledge related to conceptual *specific topic teaching strategies* and to *student understanding* (see Appendix 16).

T22's advanced PCK is not surprising, given that she has 25 years of teaching experience. What is surprising is that she was able to integrate that PCK with the new TK she had learnt during the SLP to display admirable TPACK. It seems reasonable to expect a non-user to progress into the first phase of ICT integration during the course of an intervention such as this SLP. However, T22 was clearly operating beyond the dependence phase, in which a teacher is usually so concerned with the technical aspects of ICT usage that they are unable to focus on pedagogy (Clarkson & Oliver 2002). Instead, she seemed to be operating at the counter-dependence phase by the end of the SLP, since she was using ICT in a teacher-directed manner.

5.3.3.3 Comparison of this example with the rest of this group

There are several ways in which T22 is atypical of the other members of the group into which I categorised her. Nevertheless, some of the characteristics of her experience with the SLP were shared by others in this group. In this section, I compare and contrast the description of T22's experience across the short learning programme with that of other members of this group, so as to give a clearer picture of the range of experiences within this group. All the data available, i.e., questionnaire, final task submission and interview data, are drawn on to make these comparisons.

T38, T34, T5, T19, T39, and T50 did not use ICT in their final assessment tasks, and therefore they will not be discussed in this section. It should be noted, however, that this does not necessarily mean that they did not know how to use ICT, since they had been told that this was not obligatory for the final assessment task.

Although T33 and T22 taught in completely different environments, they were both experienced teachers who started the short learning programme having had little prior exposure to ICTs. T33, like T22, demonstrated competent use of ICTs in a pedagogically meaningful way in the final assessment task. She used the Ping Pong Ball Cannon direct measurement video provided offline with the software package to promote mechanics learning and problem solving, using the tablets available in her rural quintile 1 school. These specific direct measurement videos have been created by Peter Bohacek, and demonstrate various physics concepts in a manner which allows measurement of relevant variables when the video is watched frame by frame (click here for some examples). Only certain offline video-play-back applications, such as Quicktime and VLC player, allow for this frame-by-frame stepping, and it is not necessarily intuitive to the user how to access these functions. This technological knowledge, as well as the pedagogical knowledge of developing problem-solving skills, were addressed in the short learning programme on 09/09. T33 loaded the Ping Pong Ball Cannon video onto the tablets of her school, and the learners engaged hands-on with these videos. In the video a ping pong ball is shot at high velocity at a tin can. The time between each frame in the video is provided, and a ruler placed behind the ping pong ball's path allows for the measurement of the displacement of the ping pong ball between successive frames. T33 required her learners to access this information by interacting with the videos, and then to use this to calculate the velocity of the ping pong ball before its impact with the can. Although T33's final assessment task did not reveal the level of depth of pedagogical reasoning and justification of T22's task, implementation of such a learner-cantered and cognitively ambitious lesson, particularly within a rural quintile 1 school, seems to demonstrate the presence of considerable TK and PCK. Therefore T33, like T22, did not seem to be operating in the dependence phase of ICT integration by the end of the SLP.

In contrast to the very positive extents of development of TPACK, suggested by the discussion above, T34 is an example of a participant who indicated, at the beginning of SLP, that she did not know much about ICT. At the end of the SLP, she was still struggling to use ICT in her every-day life, let alone in her teaching:

> *"I do not know much about ICT. I am even struggling with a simple cell phone that everyone is addicted to. I am still struggling with ICT after the programme" (Interview, T34, 23/09/17).*

5.3.4 Experience of teachers who started the short learning programme in the dependence phase

5.3.4.1 The teachers in the dependence phase category

Consistent with these teachers' categorisation in the dependence phase of ICT integration at the start of the short learning programme, the following extract suggests that at the start of the short learning programme the teachers categorised in this group were comfortable with using ICT for their own use, but were using ICT in a limited manner, if at all, in their teaching:

> *"Because I am not big on ICT, in terms of teaching and learning. I am big on the use of ICT for myself" (Interview, T 43, 23/09/17).*

Table 5-4 gives some biographical details of these teachers. This group is relatively young. Only three were above 36. It is therefore not really surprising that their PCK was fairly limited at the start of the short learning programme, as suggested by this comment:

> *"I always thought that teaching is about content only. I did not give much attention to pedagogy. I only learned in this programme that content delivery goes hand in hand with pedagogy" (Interview, T10, 22/09/2017).*

The group also covers the full spectrum of the South African teaching context regarding school location and quintile. All of the teachers except T12 reported having computers at their schools. T12 reported that at his school there is one computer used by the school's clerk to capture learners' marks *(Interview, T12, 22/09/2017).* Of these 22 teachers, eight participated in the interviews, and of these, I chose T53 as the example to describe in detail in this section, since he was the most eloquent about his experience in using ICT in his school during and at the end of the SLP.

Table 5-4: Teachers classified as starting the SLP in the dependence phase of ICT usage

Teacher code	Age range	Teaching experience	School quintile	School situated	Qualifications
T10	26 - 30	1 Year	3	Rural	BEd Hons
T12	31 - 35	6 Years	2	Township	BEd
T14	41 – 45	17 Years	2	Rural	BEd Hons
T15	31 - 35	3 Years	3	Township	BEd Hons
T26	46 - 50	10 Years	1	Rural	BEd Hons
T27	31 - 35	2 Years	2	Township	BSc
T40	36 - 40	13 Years	5	Urban	BEd
T42	26 - 30	6 Years	2	Urban	BEd
T43	31 - 35	5 Years	4	Rural	BEd Hons
T44	21 - 25	1 Year	1	Rural	BEd
T53	31 - 35	7 Years	3	Rural	BEd Hons
T3	26 - 30	5 Years	1	Township	BEd Hons
T9	21 - 25	3 Years	2	Rural	BEd
T16	31 - 35	3 Years	3	Urban	BEd Hons
T25	31 - 35	8 Years	2	Township	BEd
T28	26 - 30	6 Years	3	Rural	BEc
T29	26 - 30	2 Years	2	Township	BSc
T30	31 - 35	6 Years	1	Rural	BEd
T41	26 - 30	5 Years	1	Township	PGCE
T48	26 - 30	8 Years	4	Urban	BSc
T49	26 - 30	3 Years	3	Rural	BEd
T51	31 - 35	12 Years	3	Urban	BSc

5.3.4.2 The experience of one of these teachers during the course of the SLP

T53 teaches at a state school located in a rural area, which tends to show the greatest degree of dysfunctionality amongst the spectrum of South African schools (Fish et al. 2017). At his school there are high learner numbers, and the available computers are used by Computer Application Technology (CAT) learners only (*Interview, 22/09/2017).* Consequently, he said that he did not have access to the computers. During the interviews at the end of the SLP (22/09/2017), T53 reported that he started the SLP with moderate ICT skills, which improved, as did his confidence to use them in his teaching:

> *"In my case the confidence has improved a lot, I can do lesson preparations so when I go to class believe you me that my confidence level has improved up to 100%" (Interview, T53, 22/09/2019).*

For the final assessment task, T53 reported having used inquiry-based teaching (see Table 5-1). The ICT he used was the circuit construction kit Phet simulation. The teachers had been provided with all the relevant PhET simulations for offline use, on their micro-sd cards. T53 required the learners to determine how changing the resistance of bulbs affects their brightness when connected in series or parallel. Learners were given a worksheet to complete. The teacher first demonstrated how to use the Phet simulation using a laptop and smartboard. After this, the teacher asked one learner to stand in front of the class and do the investigation on behalf of the other learners. While the chosen learner manipulated the variables on the Phet simulation to answer questions in the worksheet, the rest of the class noted observations in writing in the worksheet.

It is evident from this description that T53 can use ICT as reported in his pre-questionnaire, final assessment task, and in his interview. However, the context of the school negatively affected how he could use ICT in a pedagogically meaningful way. For example, he reported having used inquiry-based learning in his final assessment task. In inquiry-based learning, which is open in the design of the procedures, learners devise their own procedures to solve the problem (Heick 2019). The SLP session on inquiry had led teachers in such a process. However, in this lesson the simulation was used in a confirmatory, demonstrative manner, rather than as part of an open-ended inquiry. The high number of learners and non-availability of computers resulted in a learner being chosen to do the Phet simulation on behalf of the other learners. This demonstrates the role that the school context plays towards the use of digital technologies (Lucking et al. 2012). Fullan and Langworthy (2013) therefore argue that the context of a school should be considered when trying to understand someone's experience with technology.

5.3.4.3 Comparison of this example with the rest of this group

Most educators in this group, including T53, used technology in a teacher-directed manner, as illustrated by the description of T53's final assessment task lesson above. This is to be expected of teachers who begin a SLP at the dependence phase, and should therefore be expected to progress into the counter-dependence phase of ICT integration (Clarkson & Oliver 2002) during the course of the SLP. An example is given below of a teacher (T44) who displayed a high level of similarity to the described example above, as well as to the teacher (T12) who did not follow the trend for the group as described above.

Like T53, T44 teaches at a low quintile school with high learner numbers. T44 also reported having used inquiry-based learning using the same circuit-construction Phet simulation used by T53. Unlike T53, T44 manipulated the Phet simulation himself for the entire duration of the class, rather than giving learners the opportunity for hands-on experience with the simulation. While T44 did this, his learners completed an associated worksheet. T12, in contrast, used inquiry-based learning with this Phet simulation in a discovery-based, learner-centred manner, enabling learners to discover the relationship between current strength and potential difference in parallel and series circuits, if resistance is maintained constantly.

5.3.5 Experience of teachers who started the SLP in the counter-dependence phase

5.3.5.1 The teachers in the counter-dependence phase category

Table 5-5 gives some biographical details of the teachers categorised as starting the SLP in the counter-dependence phase. This group is relatively young, with only four being older than 35. The group also covers the full spectrum of the South African teaching context regarding school location and quintile. Of these 10 teachers, five participated in the interviews, and of these I decided to choose T24 as the example to describe in detail for this section. He was a very interesting case, showing a very exploratory approach to technology to enhance teaching and learning. This is captured in the extract below.

"I did have expectations. I expected to learn new things that I can use to improve my style of teaching and that has been accomplished" (Interview, T24, 23/09/17).

Table 5-5: Teachers classified as starting the SLP in the counter- dependence phase of ICT usage

Teacher Code	Age Range	Teaching Experience	School Quintile	School Situated	Qualifications
T1	26 – 30	3 Years	2	Rural	BEd
T13	21 – 35	2 Years	3	Township	UDES
T17	36 – 40	9 Years	4	Urban	BSc
T21	51 - 55	31 Years	2	Rural	BEd Hons
T23	26 – 30	3 Years	3	Township	PGCE
T24	26 – 30	4 Years	2	Township	BSc
T32	31 - 35	10 Years	5	Urban	BSc Hons
T45	26 - 30	5 Years	2	Rural	PGCE
T46	46 - 50	19 Years	4	Township	BEd Hons
T4	36 - 40	11 Years	4	Urban	BSc Hons

5.3.5.2 The experience of one of these teachers during the course of the SLP

T24 teaches at a public school located in a township area. T24 reported that he integrated ICT in his lessons before the SLP, but that the SLP has expanded the pedagogical range of this usage. His reference to enhanced abilities to address learners' needs using technology, suggests that he has progressed into the independent or interdependence phases of ICT integration. In these phases, technology usage becomes second nature, and therefore the teacher can focus more on learner-centred and innovative pedagogies (Clarkson & Oliver 2002):

"I previously used ICT, but I was not using it the way I am using it now, especially to teach, assess and identify mistakes that learners do in Physical Sciences. One of the reason is that I am like these kids. I like new things. When something is new I would want to learn about it. I had extra classes and you would find that afternoon this kids are just tired and they just want to leave. This programme exposed me to how do I get learners to be more involved even if they want to leave. So I saw the opportunity because the programme was talking about ICT and a little bit of less chalk board and more of technology which is what these

> *kids like. Whether it is in the afternoon or in the morning, they would be 100% involved" (Interview,T24,23/09/17).*

During the SLP, T24 created a website for his class using Google Sites, even though this was only modelled in the short learning programme, and not explicitly taught. It was clear that he implemented what he had learnt in the short learning programme for the improvement of his learners' learning, rather than only for the aim of the final assessment task. For example, he started a "Student of the month" feature on his website. He also posted photographs of all the learners who achieved 80% and above in Physical Sciences. For the final assessment task, T24 chose the pedagogy Competition (see Table 5-1). He used PowerPoint and Plickers to teach the mole concept of stoichiometry, even though Plickers was only briefly mentioned in the SLP, rather than taught explicitly. Plickers is an assessment tool that can be used to do a quick formative assessment to measure if learners have grasped a particular concept or skill through multiple choice or true/false questions. Each learner is given a Plickers card with a unique visual code (see Figure 5-1). After projecting a multiple-choice question, each learner holds their Plickers card at the orientation relevant to the option of their choice, after which the teacher scans the cards using the mobile app, which captures and displays the learners' responses.

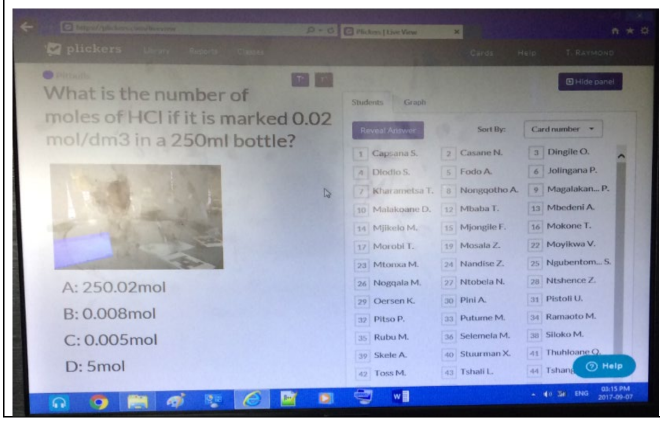
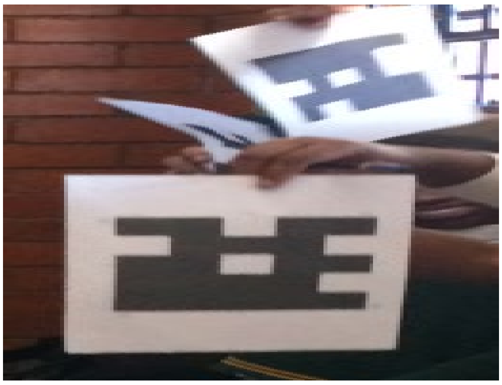
Picture 1: Multiple choice question and registered learners	Picture 2: Learners raising the Plickers cards to answer
	

Figure 5-1: *Pictures of multiple-choice question and how learners raised Plickers cards to answer*

T24 reported that his learners were actively involved and excited in the class and tended to race one another and be very focused on winning. He reflected that although this had a motivating effect on the learners, he was concerned that it might have negatively affected their learning at times. He also reported that he noticed some learners guessing the answers. In his reflective essay, he discussed ways to change his practise to improve learning in the future. This description demonstrates that T24 integrates ICTs in an innovative and explorative manner and has strong TPACK.

5.3.5.3 Comparison of this example with the rest of this group

T1, T4, T13, T17, T21, T23, T24, T32, T45 and T46 have relatively varying teaching experiences, and started the SLP with high technological knowledge. They demonstrated competent use of ICT in a pedagogically meaningful way in their final assessment task. For example, T46 used the Ping Pong Ball Cannon direct measurement video provided offline within the software package to promote mechanics learning and problem solving, using the computers in her quintile 4 school (cf. 5.3.3.3). However, not all teachers in this group implemented learner-centred lessons, as might be hoped if they had progressed into the in- and inter-dependence phases of ICT integration (Clarkson & Oliver 2002). T1, T17, T21, T23 and T13 used ICT in a teacher-directed manner, while T45, T32, T46, T4 and T24 used ICT in a learner-directed manner.

5.4 CONCLUSION

In this chapter I described the short learning programme which was aimed at promoting technological knowledge and TPACK. This description suggests a very ambitious programme aimed at helping teachers from a wide range of backgrounds, teaching contexts and initial ICT-competences to develop advanced technological, pedagogical and science content knowledge. Further, this was the first time that this SLP was presented, and it was developed within a very short period due to logistical reasons. This resulted in several technical problems which could have been avoided if more time had been allowed for its development, and which would probably be ironed out in later versions of the short learning programme. Despite these challenges, the descriptions provided suggest that many teachers were able to progress to the next phase, or even beyond, in their ICT integration journey, according to the phases described by Clarkson and Oliver (2002). However, the descriptions also highlighted the frustration and lack of progress experienced by some of the teachers. Table 5-6 provides a summary of this chapter.

Table 5-6: Synopsis of the description of the case

Issues	Summary/Sense making	Section
The short learning programme	This SLP is a South African context-based programme targeting Grade 10 Physical Sciences teachers.	5.2.
Context and philosophy of the programme	It is a face-to-face programme intended to promote TPACK.	5.2.4
Teachers' experiences	The teachers experienced the SLP differently.	5.3
Biographical contexts of teachers	Teachers come from diverse contexts: quintile 1 – 5 schools located in urban, rural and township areas.	5.3.1
Initial technological knowledge	There is a wide range of ICT competence among the teachers in terms of the four phases identified by Clarkson and Oliver (2002). These are dependence, counter-dependence, independence, and interdependence. 'Non-usage' was added to describe the phase before teachers begin using ICT in teaching.	5.3.2
Experiences of teachers with the SLP	Some teachers found the use of ICT to teach challenging, for some it was not so challenging, and for others it was what they have been longing for in their teaching career.	5.3.3.-5.3.5.

In the next chapter, the results of the qualitative and quantitative sample data are analysed and interpreted. The analysis and interpretation are done in terms of the theoretical framework discussed in Chapter 3, the literature review in Chapter 2, and guided by the study's research questions.

CHAPTER 6: ANALYSIS AND INTERPRETATION

6.1 INTRODUCTION

This chapter focuses on the analysis and interpretation of the collected data. Both qualitative and quantitative data were collected for the study, using a variety of tools. The chapter is structured according to the relevant secondary research questions posed at the start of the study. Secondary research questions 1 to 5 will be discussed, based on the qualitative and quantitative data gathered from the questionnaires, interviews, observations, and the final assessment task.

Several claims are made to answer the research questions, and each of these claims is then supported by reference to the data of the study. It is important to note that these claims refer to what emerged from this study. The numbering of these assertions correlates with how the research questions follow each other.

6.2 CHANGE OF TEACHERS' PERCEPTIONS REGARDING THE USE OF ICT

Assertion 1: Through the course of the professional development opportunity aimed at promoting TPACK, the teachers' knowledge and confidence to use ICT improved. Both before and after the programme teachers were very optimistic about the potential of ICT to improve the effectiveness and efficiency of the teaching and learning of Physical Sciences. This optimism was slightly tempered across the course of the programme. The teachers perceived that their integration of ICT usage into their Physical Sciences teaching improved across the course of the programme. However, the teachers' perceptions regarding the extent to which they could access ICT resources daily, and to which their principals expected and encouraged them to use ICT to teach Physical Sciences, remained low throughout the course of the professional development.

To understand how teachers' perceptions regarding the use of ICT changed through the course of the professional development aimed at promoting TPACK, I compared their perceptions before and after the training, using the paired t-test method. Table 6.1 below shows the results of how teachers' perceptions changed.

Table 6-1: Comparison of post- and pre-values (n=53)

Variable	Statistic	Mean		Mean difference: Post – Pre			
		Pre (/5)	Post (/5)	Point estimate[1]	95% Confidence interval[1]	t-statistic[2]	P-value[2]
Perceived ease of use	Mean	3.48	4.15	0.67	0.39 to 0.96	4.71	<0.0001
	SD	0.94	0.88				
Perceived usefulness	Mean	4.53	4.28	-0.25	-0.41 to -0.08	-2.93	0.005
	SD	0.56	0.60				
Usage	Mean	3.48	3.89	0.41	0.24 to 0.58	4.82	<0.0001
	SD	0.78	0.73				
Perceived behavioural control	Mean	3.11	3.08	-0.03	-0.29 to 0.23	-0.25	0.807
	SD	1.12	0.99				
Subjective norms	Mean	3.68	3.45	-0.23	-0.53 to 0.08	-1.50	0.139
	SD	1.04	0.96				

[1]Point estimate and 95% confidence interval of the mean difference “post-pre”.
[2]Paired t-test (df=52) and P-value for of the null-hypothesis that the mean difference is 0.

6.2.1 Perceived ease of use

Assertion 1.1: The teachers’ knowledge and confidence to use ICT to teach Physical Sciences improved through the course of the professional development opportunity.

Perceived ease of use refers to how confident teachers feel about using computers, data projectors, smartboards, tablets, and cell phones as resources for teaching Physical Sciences. When teachers feel confident to use technology, they are more likely to use it. Scherer, Siddiq and Tondeur (2018) have noted perceived ease of use as a critical element that influences the use of technology. They described it as the extent to which teachers believe that using ICT resources in Physical Sciences would not require too much effort. Therefore, it refers to the person’s estimation of the effort it would take to use technology in the teaching of Physical Sciences, and is connected to beliefs about competency (Scherer, Siddiq & Teo, 2015).

The findings in this study revealed that the teachers' perceived knowledge and confidence to use computers, data projectors, smartboards, tablets, and cell phones as resources to teach Physical Sciences improved statistically significantly ($p<0.05$) through the course of the professional development: M = 3.48(/5) (SD = 0.78) before the programme and M = 4.15(/5) (SD = 0.88) after the programme. This improved knowledge and confidence matched the teachers' purpose of joining the training, which was to learn more about ICT and how to use it in the teaching of Physical Sciences.

The qualitative results confirmed that teachers in this study improved their knowledge to use ICT during the programme and found it easy to use it in the teaching of Physical Sciences. T10 said:

> *"The programme helped me to grow in my teaching and content delivery. I am now confident to use cell phones to teach my learners as there are no computers or tablets in my school. The more confident I am as a teacher, the more confident my learners will be in getting their knowledge from me" (Interview, T10, 22/09/17).*

Exposure and support are related to perceived ease of use of ICT (Chikasa, Ntuli & Sundarjee 2014). In this study, teachers were exposed to how to use ICT to teach and were given technical support across the programme. In this study, 13 of the 17 interviewed teachers self-reported feeling confident to use ICT during the teaching of Physical Sciences, even though various researchers such as Peeraer and Petegem (2011), Aslan and Zhu (2016), and Msila (2015) revealed that teachers in general do not use ICT because of a lack of skill and training. As previously mentioned, T10 ascribed this feeling of confidence to use ICT to the training received in this short learning programme:

> *"The programme helped me to grow in my teaching and content delivery. I am now confident to use cell phones to teach my learners as there are no computers or tablets in my school. The more confident I am as a teacher, the more confident my learners will be in getting their knowledge from me" (Interview, T10, 22/09/17).*

Tasir, Abour, Halim and Harun (2012) found that teachers' confidence levels towards using ICT were correlated positively to their competence in technology ($r = 0.749$, $p<0.05$). Technology confidence means that teachers believe that they can use ICT tools effectively, and that they can integrate these tools into their teaching process.

Several teachers in this study expressed how they improved their ways of using technology due to the knowledge and skills gained during the training *(Interview, 22/09/17 & 23/09/2017)*. For example, this is what T11 indicated:

> *"In my case the confidence has improved a lot due to the fact that even if I am in a bus, at least have my tablet. I can prepare anytime what I want, I can watch videos and simulations. So, for preparation purposes I have everything at my disposal and at any time, so when I go to class believe you me that my confidence level has improved up to 100%, now that the information is readily available" (Interview, T11, 22/09/17).*

Chikasa et al. (2014) assert that teachers who find it easier to use ICT are more likely to use technology frequently in their teaching and learning. On the other hand, teachers who doubt that technology will work when they need it, will be reluctant to use it in their teaching and learning (Chigona, Chigona, Kausa & Kayongo 2010). The improvement in the teachers' perceived ease of ICT usage in the teaching of Physical Science, in this study, therefore, suggests that these teachers are likely to have improved their usage of ICT in their teaching. However, this is not certain, since ICT uptake is influenced by other factors as well.

6.2.2 Perceived usefulness

Assertion 1.2: Both before and after the programme, most teachers were very optimistic about the potential of ICT potential to improve the effectiveness and efficiency of the teaching and learning of Physical Sciences, with this optimism being slightly tempered across the course of the programme.

Perceived usefulness is described as the degree to which a person has a strong belief that his or her job performance will greatly improve when technology is used (Davis et al. 1989). Perceived usefulness is recognised as having a huge impact on the adopters' intention to use technology. Previous research found that perceived usefulness strongly predicts teachers' attitudes towards successful implementation and the effective use of technology (Buabeng-Andoh 2012; Fu 2013; Sabzian & Gilakjani 2013; Deng et al. 2014; Ertmer, Ottenbreit-Leftwich & Tondeur 2015; Farrukh & Singh 2014; Teo, Fan & Du 2015; Govender & Govender 2009). In this study, the perceived usefulness construct was measured using statements about whether teachers perceive technology to enhance the effectiveness and efficiency of teaching and learning.

Before the programme, teachers in this study had high expectations that ICT would enhance their success and productivity of teaching and learning (M = 4.53(/5); SD =.0.56). However, this dropped to M = 4.28(/5) (SD = 0.60) by the end of the programme. This value is still very high, even though statistically significantly lower than the initial value ($p<0.05$). This seems to suggest that the participants developed a more realistic, while still very positive, view of the usefulness of ICT in teaching during the programme.

The teachers' perception before the training that technology is effective and efficient to improve teaching and learning, could mean that their intentions of using technology at schools are good (Hart & Laher 2015). Conversely, even if teachers hold the belief that the use of technology can assist them to achieve personal and professional tasks more efficiently and effectively, they may be resistant to integrate the same tools into the classroom for various reasons, which include insufficient knowledge (Lawless & Pellegrino 2007; Yuen & Ma 2002; Venkatesh & Davis 1996). According to Mathipa and Mukhari (2014), teachers tend to resist ICT integration in teaching because of the belief that ICT holds no advantages for their learners and themselves. Such teachers are likely to avoid using technology in the classroom (Chikasa et al. 2014; Teo et al. 2008).

Teachers in the sample held favourable attitudes towards general usage of ICT in their teaching. It is undisputed that teacher attitudes are critical in determining whether teachers will adopt ICT or not. The teachers in this sample generally expected the outcome of ICT usage to positively impact on their teaching. They also believed that technology could help them to achieve professional or personal tasks more efficiently *(Assessment tasks, Interview, 22&23/09/17).* Benefits of the effectiveness and efficiency of using ICT in the teaching and learning of Physical Sciences in this study were mentioned by some teachers:

- Where there was no apparatus to perform experiments, teachers downloaded such experiments from YouTube and other apps *(Interview, 22&23/09/17).*

- They used the apps and sites they were exposed to during the training to teach and access useful information regarding Physical Sciences. An example of such an app was Photo Math. Teachers expressed how excited their learners were when they were exposed to the app *(Interview, 22/09/17 & 23/09/2017)*. A teacher even commented by saying:

  "If every teacher can use ICT in his or her teaching, the teaching will no more be boring and certainly learners will never absent themselves from school. Our learners will forever be excited to be at school and ready to explore the world" (Interview, T24, 23/09/17).

The following benefits of using ICT experienced by the participants in this study are described in detail in paragraphs 6.5.1 to 6.5.5 *(Interview, 22&23/09/17)*:

- Use of ICT leads to better ways of teaching and learning
- Use of ICT improves learner motivation and participation
- Use of ICT influences teacher professional growth
- Use of ICT promotes learner independence and collaboration
- Use of ICT improves learner performance

Coupled with the above self-reported ICT benefits mentioned by the teachers in general, T22 is a unique participant who was also exposed to the benefits of using ICT. She discovered the many benefits of ICT for herself and her learners, even though she was a first time ICT user. This is seen from her final assessment task, which is discussed in detail in paragraph 5.3.3.2. She was able to integrate her PCK with newly acquired TK to display admirable TPACK. However, she made it clear that she would never completely replace doing hands-on experiments with equivalent ICT-based activities *(Assessment task 1 & 2 & Interview, T22, 23/09/17)*.

6.2.3 Use of ICT

Assertion 1.3: The teachers in this study perceived that their integration of ICT usage into their Physical Sciences teaching improved across the course of the programme.

ICT use is understood as an indicator of ICT acceptance. ICT use can either be observed or self-reported. ICT usage may be observed during classroom visits, which could not be conducted in this study. As a substitute for classroom visits, the final assessment task required teachers to video and report on a lesson in which they had used ICT. This enabled me to evaluate usage through some form of observation. In this section, I report on the teachers' responses to self-reported questionnaire items regarding their ICT usage.

The teachers' perceptions that they used ICT during the teaching of Physical Sciences improved statistically significantly across the course of the programme: M = 3.48(/5) (SD = 0.78) before and M = 3.89(/5) (SD = 0,73) after the programme ($p<0.05$). As previously discussed, Scherer et al. (2018) showed that perceptions of ease of ICT usage improved ICT usage. This is consistent with this study's finding, that the participants' improved perception of ease of use of ICT was coupled with improved usage of ICT during teaching.

T10 indicated that he is now using computers daily to teach Physical Sciences, in contrast to low computer usage before he joined the programme:

> *"We are indeed living in a world that requires us to use technology. Before I joined the programme, I used computers once or twice in a week. Sometimes not at all. But since I joined this programme, I am using a computer daily. The programme has exposed me to the benefits of using technology to teach, so I cannot just get enough of using it to teach Physical Sciences" (Interview, T10, 22/09/17).*

What T10 said gives evidence that the teacher was provided with technical knowledge and teaching skills. This is why there was a noticeable change in how they used ICT to teach Physical Sciences after the training. It is remarkable that the teachers in this sample reported improving their use of ICT to teach Physical Sciences, because South African teachers are known to resist the uptake of ICT use, and that this is related to their preference of "traditional methods of teaching which hinder the growth of skills of the 21st-century student" (pp. 566) (Blignaut, Els & Howie 2010). This resistance is understandable if teachers lack prior technical knowledge and do not understand how ICT can impact their teaching (Tedla 2012).

In one of the statements to measure "usage", teachers were asked to indicate if they were using computers for administrative purposes. Before the training, the teachers indicated that they mainly used computers for administrative purposes such as entering marks (M = 4.04(/5); SD = .24). However, after the training, there seems to have been a decline in how computers were used this way since (M = 3.89(/5); SD = 1.46), suggesting a shift in the perception of how computers are used.

In contrast, the participants' perceptions of the extent to which they used computers and cell phones for email and to access the internet already high before the course, increased slightly, through the course (M = 4.53(5); SD = 0.95) to (M = 4.74(5); SD = 0.65) and (M = 4.68(5); SD = 0.67) to M = 4.74(5); SD = 0.81). Stols (2008) argues that practices where computers and cell phones are used for email and accessing the internet are easily adopted by teachers, since they require no pedagogical change. In contrast, ICT integration into teaching requires pedagogical change. In this training, teachers were exposed to different pedagogies that could guide them to appropriate technologies to use during teaching. It is beyond the limitations of the available data to make claims about what the participants practiced daily in their classrooms after the programme. However, the final assessment tasks suggested that the teachers were able to apply different learned pedagogies to teach Physical Sciences content by the end of the programme (as explained in sections 5.3.3, 5.3.4 & 5.3.5).

6.2.4 Perceived behavioural control

Assertion 1.4: Most teachers' perceptions regarding the extent to which they could access ICT resources daily to teach Physical Sciences remained low through the course of the professional development opportunity.

Perceived behavioural control is described as a person's perception of how difficult or easy it is to execute a task based on the opportunities and resources available to the person (Ajzen 1991). In this study, perceived behavioural control was established by statements measuring the teachers' perceptions regarding the daily access of computers, data projectors, smartboards, and tablets, and support in the use of these resources. Perceived behavioural control also refers to the teachers' perceptions regarding learners' access to computers, tablets and cell phones during teaching and learning of Physical Sciences. The findings in this study revealed that there was no significant difference in the teachers' perception of the control they had over their behaviour with use of ICT in teaching Physical Sciences ($p > 0.05$). This finding corresponds to the interview data in which some teachers self-reported that they and their learners could not easily access computers, data projectors, smartboards, and tablets, and support when using of these resources *(Interview, 22/09/17 & 23/09/2017)*. The finding that these perceptions were unchanged by the programme may indicate that these access constraints are real, rather than merely being perceptions, and that addressing these constraints may be beyond the agency of these teachers. The detailed discussion on this self-reported non-accessibility of ICT resources by teachers and how it impacted on ICT integration is found in an answer to research question 3 in paragraph 6.3.2.2.

The South African Department of Basic Education has invested financially in providing ICT resources to schools (DBE 2015). In the Free State province, most schools have received donations of electronic equipment (Jacobs 2018). However, findings in the literature reveal that the use of computers in most South African schools is limited or completely absent (Jacobs 2018; Stott 2021). As discussed in 6.3.2.2., despite this presence of ICT in most Free State schools, teachers are often unable to access these for use in the teaching. The limited or non-access to computers is a first-order barrier towards technology use (Sherman & Howard 2012), particularly in low quintile schools (Stott 2021). Most of the teachers in this study come from low quintile schools where they experience limited or no access to computers (as explained in section 6.3.2.2).

Hennessy, Harrison, and Wamakote (2010) agree that the limited or non-access to ICT resources in most schools is a complex barrier that influences change in teachers' practice. According to the theory of planned behaviour, the general lack of access to ICT resources experienced by many of the participants which likely caused the observed insignificant change of the participants' perceived behavioural control across the programme, should have resulted in no improvement in ICT usage. However, this was not the case. As discussed in 6.3.2.1 and 6.3.2.3, several participants found ways to improvise their ICT access within the constraints of their environment.

6.2.5 Subjective norms

Assertion 1.5: Most of the teachers' perceptions regarding the extent to which their principals expected and encouraged them to use ICT to teach Physical Sciences remained low through the course of the professional development opportunity.

Subjective norms refer to expectations from significant others, for example from learners and principals, that teachers should use ICT in their teaching. Subjective norms may also include interpersonal influences from friends, colleagues or family members, as well as external influences such as different types of media reports and expert ideas (cf. 3.3.3). Altawallbeh, Soon, Thiam and Alshourah (2019) described SN as a construct that places an expectation on Physical Sciences teachers to use ICT. Al Haderi and Aziz (2015) also presented subjective norms as an outcome of each teacher's reaction to the perceived expectations from management and colleagues. This also includes the personal belief that teachers must respect those expectations (Aversano 2005).

No significant difference was measured across the course of the programme regarding the teachers' perceptions in terms of the subjective norms exerted by their principals and learners to use ICT in teaching Physical Sciences ($p > 0.05$). This finding is unsurprising since the programme had not targeted the principals or learners. Teachers further perceived that their principals did not encourage or expect them to use ICT during the teaching of Physical Sciences in this study.

If options 1 - 3 in the Likert scale used in this study as indicating a degree of negativity or indifference towards the questionnaire statements, then 68% and 63% respectively of the teachers indicated that their principals did little to show expectations (SN1) or encouragement (SN2) regarding their use of ICT in their teaching (Figure 6.1). In contrast, as shown in Figure 6.1., the teachers perceived their learners as wanting them to use ICT in their teaching, although in my experience, it is unlikely that the learners' views were considered to weigh much towards the subjective norms experienced by the teachers.

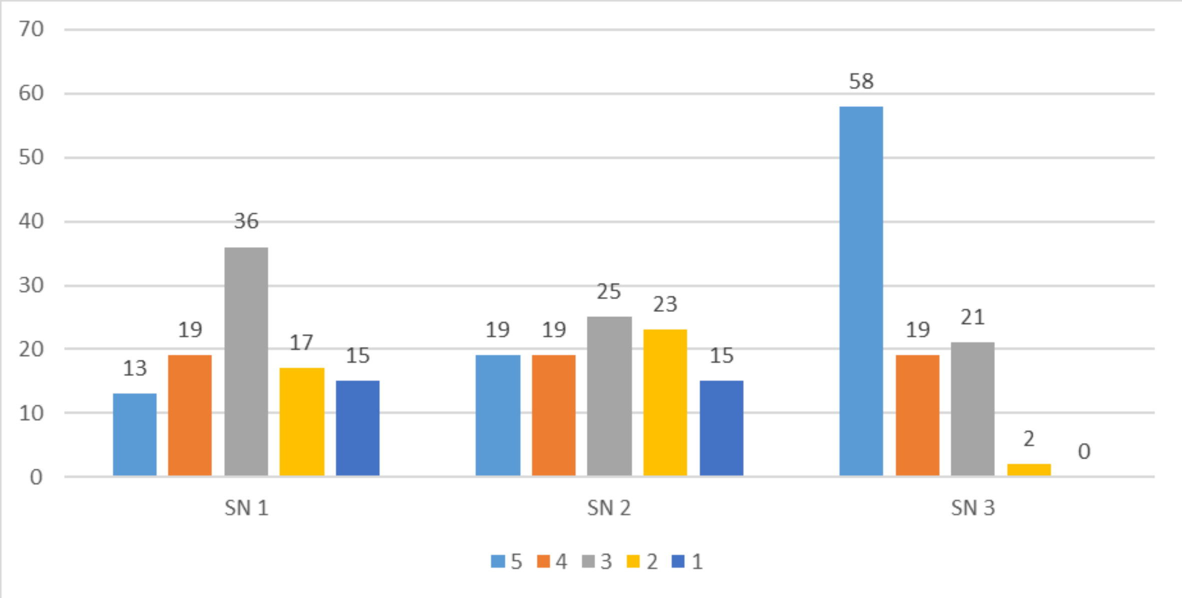


Figure 6-1: Percentage of participants who chose each option in a 5-point Likert scale for items related to the subjective norm regarding use ICT in teaching and learning after training

The subjective norms exerted by principals is known to affect teachers' uptake of ICT. For example, Ghavifekr and Rosdy (2015) noted that teachers need motivation and support from the school's top management team to use ICT during teaching. Mathipa and Mukhari (2014) argue that poor management in the school environment does not support a change in school ICT use. In the interviews conducted by Mathipa and Mukhari (2014), one primary school teacher indicated that their computer laboratory is always locked during school hours and is dysfunctional. According to this teacher, this is because the school management team, which controls their laboratory, does not understand the usefulness of computers.

In contrast, when support and motivation are provided by the principal or school management team, teachers are more motivated and willing to integrate ICT. In addition to feeling motivated, teachers also feel that their efforts are acknowledged by the principal or school management team. The principal or school management team should be aware of the critical role they play in teachers' lives, especially when they appreciate the work teachers do. Kannan et al. (2012) position the principal as a technology leader, the one who should envisage opportunities for the use of ICT during learning and teaching. Afshari et al. (2009) say that the principal, as the transformation leader, needs to be fluent in basic information technology, and must be an ICT user to encourage teachers to use ICT and to develop their computer literacy skills. By so doing, he or she becomes a mentor to the school community.

However, it was clear from the focus group discussions that not many of the principals of the teachers in this study expect and encourage ICT integration in subjects such as Physical Sciences (as discussed in sections 6.3.2.1 – 6.2.3.4). One of the reasons given was that the principals see the school computers as intended for Mathematics, Computer Applications Technology and administrative purposes (as discussed in section 6.3.3.2). For example, a teacher from a well-resourced school was denied use of the media centre, which has ICT resources, by the school management team *(Interview, T34, 23/09/21).* Another teacher who was denied access to the use of tablets at his school strongly feels that principals, head of departments and school governing bodies must attend this type of programme. This is how T1 felt:

> *“I really think that principals must attend these programmes. You explain to the principal, principal one two three is very interesting. I tend to find that our principals are still in that old school’s leadership style. They still believe in old school of doing things. The principal will tell you that you are just new and you want to tell me to change how I do things. One another thing is that head of departments have to come. It should be for the whole school and if principals, head of departments, leadership in general are at the workshops then they would know. I also think school governing body member must also attend such programmes, even if they do not learn the content but they would understand how the programme does and what it is all about” (Interview, T1, 22/09/17).*

Another reason for principals’ reluctance to support ICT integration, is their fear of the risks associated with its use, as alluded to by T53:

> *“I had to ask the facilitator to write me a letter confirming that I have enrolled in the ICT training and the nature of this programme require that learners also have gadgets. I took the letter to the principal to allow my learners to bring their cell phones. It was after this letter that my learners were allowed to bring their cell phones. But the sad part is that the principal told me on my face that I am on my own if anything wrong happens in his school. Clearly, he did not really support me” (Interview, T53, 22/09/2017).*

This lack of encouragement from principals for ICT integration discouraged many of the teachers in the sample (as discussed in section 6.3.3.5). Despite this discouragement, the knowledge and skills gained from the training (as discussed in section 6.2.1) seem to have been effective in allowing some of the teachers to see the value of the use of ICT during teaching and learning (as discussed in section 6.2.2), and improving their ICT uptake, as suggested in 6.2.3.

In contrast to the limited support given by many principals, as discussed above, several teachers indicated that their principals were very supportive of their integration of ICT (see Figure 6.1, page 164) One such teacher, who is also part of the school management team, expressed how supportive her school principal was towards the implementation of what was learned during the training. This is how T51 expressed her appreciation of the support she received from her principal:

> *"I want to attest on the point of leadership. I have a boss that runs the school, and I am fortunate enough to be in a leadership position where in all honesty say that I have all the favour and support in the world from my principal. I think after the first three sessions, I went back, and I just said to my boss, there is this course I enrolled for and is good. I have got only the Grade 10 programme, however there are Grade 9, 11 and 12 programmes available and this is the cost. She was not even interested as to find out what it is about, she just said if you say it is good then it is good enough for me. Let us put it in the budget and make sure that when 2018 starts we have those programmes. I am fortunate to have extremely few learners. Right now, Grade 11's are six, so because I was always making trips to computer applications technology class and stay after school because I want to show videos, our board room (which is the territory for teachers). She put in the computer and the big screen TV, and she said, anytime and anybody can book it, bring your learners. There are few teachers whose learners can fit in the boardroom. My trips and my cry over using computer applications technology class were over" (Interview, T51, 22/09/2017).*

There is an obvious need for the sort of leadership in schools which drives higher levels of ICT expertise. This is necessary for the development of a joint culture which encourages ICT to be introduced into the teaching and learning process, and for teachers to use ICT-based teaching methods (Pelgrum & Voogt 2009). Therefore, I feel that the principal, as the leader of the school and the school management team, must encourage teachers to attain the goals of education. As the connection between teachers and the Department of Education, he or she must ensure that educational transformation such as ICT usage and innovation are welcomed by all teachers. This can be achieved when funding is provided for continuous professional development opportunities such as ongoing training and workshops. This will allow teachers to access the needed ICT infrastructure and provides a conducive environment where teachers and learners could gain the knowledge and skills to use technology as expected by educational authorities.

6.3 THE RELATIONSHIP BETWEEN BIOGRAPHICAL AND SCHOOL FACTORS AND THE CHANGE IN TEACHERS' PERCEPTION REGARDING USE OF ICT

Age, gender, qualifications, teaching experience, school location, and school quintile are biographical factors that may affect how teachers' perceptions regarding use of ICT change (as discussed in sections 2.8.1 to 2.8.3). One-way ANCOVA was applied to the questionnaire data to understand how these factors are related to the extent to which the teachers' perceptions changed through the course of the professional development opportunity in terms of the use of ICT.

Availability and accessibility of ICT resources, policies controlling access to other ICT resources, infrastructure and learner enrolment, and theft are some of the school factors that teachers mentioned affected their ICT usage, as discussed in section 6.3.2.

6.3.1 Biographical factors and the change in teachers' perceptions regarding the use of ICT

Assertion 2.1: Age, gender, qualifications, school location and school quintile did not influence the teachers' perceptions regarding the use of ICT changed through the course of the professional development opportunity. The teachers in the most experienced category experienced the greatest decline in their perception of the usefulness of ICT in teaching, across the programme.

Tables 1 - 5 in Appendix 15 indicate that there was no significant difference in the change in teachers' perceptions (PU, PEU, PBC, SN and Usage) in relation to age, gender, qualifications, school location, and school quintile (p > 0.05). To understand the findings presented in Tables 1 – 5 in Appendix 15, I unpack in detail how the teachers' perceptions regarding the easy use of ICT changed across the professional development opportunity in relation to age and gender, as examples in Tables 6.2 - 6.7.

6.3.1.1 Age and perceived ease of use

Table 6.2 below indicates that the 21 - 35 age group perceived the use of ICT to be easier, on average, M = 3.64(/5) (SD = 0.94) than the 35 – 56 age group: M = 3.35(/5) (SD = 1) before the professional development opportunity. By the end of the professional development opportunity, the 21 - 35 age group greatly improved their perception regarding the ease of ICT usage: M = 4.41(/5) (SD = 0.63) than the 35 – 56 age group: M = 3.95(/5) (SD = 1.1). The change in the perception that it is easy to use ICT is greater in the 21 - 35 age group: M = 0.77(/5) (SD = 0.89) as compared to the 36 - 56 age group: M = 0.6(/5) (SD = 1.16). However, as shown in Table 2 in Appendix 15, and in Table 6.3., below, this difference was not statistically significant. Given the very high final value of the younger age group, the possibility does exist that the post-questionnaire data exhibited a ceiling effect for this group, which prevented statistical significance from being evident. In the ceiling effect, participants' views cannot be distinguished from one another within the data, or from themselves, between pre- and post-data, due to an indication of the maximum score possible despite differences in experiences. A high average score suggests that a large number of participants have chosen the maximum score possible. Further investigation would be needed, however, to verify this speculation.

Table 6-2. Change in perceived ease of use across age group

		Age Group	
		21-35	**36-56**
	N	**26**	**20**
Perceived ease of use before training	Mean	3.64	3.35
	Std. deviation	0.94	1
Perceived ease of use after training	Mean	4.41	3.95
	Std. deviation	0.63	1.1
Change in perceived ease of use	Mean	0.77	0.6
	Std. deviation	0.89	1.16

This speculation is supported by literature. Padayachee (2017), for example, found the change in the perception that it is easy to use technology among older teachers to be lower than in younger teachers. According to Hsu (2014) and Chikasa et al. (2014), older teachers as compared to younger teachers have higher degrees of technological anxiety. There are other reasons that cause older teachers to find it more difficult to use technology during teaching. Some examples include that some may feel that ICT is time-consuming, they lack basic ICT skills, and they do not understand the importance of ICT. Because of the above-mentioned reasons, older teachers may tend to continue to use old methods of teaching, despite being told what ICT can add to their teaching (Hart & Laher 2015).

Table 6-3. Age in relation to the change in perceived ease of use

Dependent variable	Demographic factor	Factor level	Mean difference			
			Point estimate	F-static	Degrees of freedom	P-value
Perceived ease of use	Age group	21-35 years	0.88	1.76	2.49	0.183
		36 – 50 years	0.51			
		>50 years	0.35			

6.3.1.2 Gender and perceived ease of use

Table 6.4 below indicates that the males in the sample perceived the use of ICT to be easier on average: M = 3.73(/5) (SD = 1.01) than females: M = 3.25(/5) (SD = 0.83) before the professional development opportunity. After the professional development opportunity, the males' perception on average, regarding the ease of use of ICT was still higher: M = 4.28(/5) (SD = 0.95) than that of the females: M = 4.04(/5) (SD = 0.81), although the change from pre- to post questionnaires was greater among females: M = 0.79(/5) (SD = 1.02) as compared to the males: M = 0.55(/5) (SD = 1.08). This change was not, however, found to be statistically significant, as shown in Table 2 in Appendix 15, and in Table 6.5., below. As for the influence of age, this finding could have been invalidated by the ceiling effect, as suggested by the very high values for the post-questionnaire for both genders.

Table 6-4: Perceived ease of use and gender

		Gender	
		F	M
	N	28	25
Perceived ease of use before training	Mean	3.25	3.73
	Std. deviation	0.83	1.01
Perceived ease of use after training	Mean	4.04	4.28
	Std. deviation	0.81	0.95
Change in perceived ease of use	Mean	0.79	0.55
	Std. deviation	1.02	1.08

In contrast with the possibility that the females in this group might have improved their perceptions of the ease of use of ICT across the programme, studies by Scherer et al. (2015) and Eickelmann, Bos, Gerick and Kahnert (2014), suggest that the change in the perception that it is easier to use ICT, to be more true of male teachers than of their female colleagues. However, the view that women tend to be more nervous than men about using technology is more likely to decrease women's self-efficacy and raise perceptions that the use of technology requires more work (Goswami & Dutta 2016), is consistent with the suggestion, from this study's data, that males were more confident with ICT use. If the lack of a statistically significant difference in the change in teachers' perceptions that it is easy to use ICT in relation to gender ($p>0.05$) is a valid finding, rather than being an artefact of the ceiling effect and limitations inherent to Likert scale use, then this finding is consistent with Aslan and Zhu's finding (2016) that gender does not influence the change in teachers' perceptions that it is easy to use ICT during teaching.

Table 6-5: Gender in relation to the change in perceived ease of use

Dependent variable	Demographic factor	Factor level	Mean difference			
			Point estimate	F-static	Degrees of freedom	P-value
Perceived ease of use	Gender	Female	0.63	0.15	1.50	0.6974
		Male	0.72			

6.3.1.3 Teaching experience and perceived usefulness

Table 6.6 below indicates that all groups of teachers, according to teaching experience, had a high perception of the usefulness of ICT in improving the effectiveness and efficiency of teaching and learning, on average, before the professional development opportunity: 0 - 5 years [(M=4.71(/5) (SD = 0.38)], 6 – 10 years [(M = 4.6(/5) (SD = 0.6)], 11 - 20 [M =4.42(/5) (SD = 0.54)], and 21+ [(M=4.12)(/5) (SD = 0.79)]. After the professional development opportunity, there is an observed drop in the perception that ICT can improve the effectiveness and efficiency during teaching for teachers with 0 - 5, 11 - 20 and 21+ years of teaching experience [(M = 4.46(/5) (SD = 0.44)] [M = 4.09(/5) (SD = 0.59)] and [M = 3.64(/5) (SD = 0.61)] respectively, while there was no change in the perception for teachers with 6 – 10 years of teaching experience: M = 4.6(/5) (SD = 0.49) that ICT can improve the effectiveness and efficiency during teaching. The change in the perception that ICT can improve the effectiveness and efficiency during teaching than the teachers decreased significantly for teachers with 21+ (M = -0.48(/5) (SD = 0.81) as compared to teachers with 0 - 5 and 11 – 20 years of teaching experience respectively: (M = -0.25(/5) (SD = 0.56); (M = -0.33(/5) (SD = 0.51). Even though there was a drop across all groups in the perception that ICT can improve the effectiveness and efficiency during teaching after the professional development opportunity, the perceptions of all groups remained high.

Table 6-6: Perceived usefulness and teaching experience

		Years of teaching experience			
		0-5	6-10	11-20	21+
	N	19	12	15	7
Perceived usefulness before training	Mean	4.71	4.6	4.42	4.12
	Std. deviation	0.38	0.6	0.54	0.79
Perceived usefulness after training	Mean	4.46	4.6	4.09	3.64
	Std. deviation	0.44	0.49	0.59	0.61
Change in perceived usefulness	Mean	-0.25	0	-0.33	-0.48
	Std. deviation	0.56	0.66	0.51	0.81

The findings in this study, as shown in Table 6.7 below, further revealed that the teachers' teaching experience influenced the change in teachers' perception that ICT can improve the effectiveness and efficiency of teaching and learning ($p<0.05$) and not PEU, PBC, SN and Usage ($p > 0.05$). It seems to me that there was a 'pie in the sky' fantasy of ICT being the magic word to solve all problems at the beginning of the professional development opportunity (as seen by the very high initial values), and then all groups became more realistic across the duration of the course. Clearly the more experienced teachers ‘tempered’ their view to a greater extent than their younger counterparts. My speculation for more experienced teachers to temper their view is that older teachers are just more sceptical and realistic, so their ‘pie in the sky’ fantasy was brought down to earth to a greater degree.

Table 6-7: Teaching experience in relation to the change in perceived usefulness

Dependent variable	Demographic factor	Factor level	Mean difference			
			Point estimate	F-static	Degrees of freedom	P-value
Perceived ease of use	Age group	0 - 5	-0.12	4.28	3.48	0.0093
		6 - 10	0.04			
		11 - 20	-0.40			
		21+	-0.74			

6.3.2 School factors and the teachers’ change regarding the use of ICT

Assertion 2.2: The availability and accessibility of ICT resources and infrastructure appropriate to figures of learner enrolment, served as barriers to the participants’ use of ICT in their respective schools. Where the schools had no ICT policies, there was inequitable access to ICT resources.

6.3.2.1 Availability of ICT resources

Several studies have confirmed the possible effects of school characteristics such as the availability of ICT resources regarding the use of ICT in classrooms, (e.g. Akbulut, Kesim & Odabasi 2007; Tallent-Runnels, Thomas, Lan, Cooper, Ahern & Shaw 2006). When ICT resources are available for usage to provide assistance, and to provide support when needed, this is referred to as the availability of ICT resources (Jebeile & Abeysekeka 2010). Ndlovu and Lawrence (2012) found that South African schools are still facing a variety of challenges when it comes to the availability of ICT resources. The findings of my study confirmed what was found in a study by Ndlovu and Lawrence

(2012) (*Interview, 22/09/17 & 23/09/2017*). Teachers self-reported various challenges they experienced in their respective schools regarding the availability of ICT resources. For example:

> ***"****At my school, we do not have laptops and computers at school. Ehmm we had tablets that we were not using. Before the programme of course. The computers are only used by the Tech, eh what is this, computer applications technology learners that's it" (Interview, T1, 22/09/17).*

> ***"****We do have 20 laptops in my school. We just recently received tablets, unfortunately, we did not have chargers and we could not use them and apparently, they were for mathematics, and I could not access them" (Interview, T11, 23/09/17).*

The attachment of computers or tablets or laptops to specific subjects made it difficult for some Physical Sciences teachers to use the available computers or tablets to teach Physical Sciences, and this resulted in conflict and tension in the school context (*Interview, 22/09/17 & 23/09/2017*).

Different schools have different levels of the availability of ICT resources in schools. This obviously has an impact on the use of technology during the teaching of Physical Sciences (*Interview, 22/09/17 & 23/09/2017*). Two of the 17 (12%) interviewed teachers in my study reported that in their schools there is only one computer used by the clerk, and this shared by the entire school to capture marks (*Interview, 22/09/17 & 23/09/2017*). In other schools there might be no computers, or a computer laboratory to be used by 60 learners or by the CAT learners only (*Interview, 22/09/17 & 23/09/2017*). One teacher mentioned that:

> *"In my school, we do have only one computer lab, unfortunately, it is only for CAT learners (Interview, T25, 23/09/17).*

ICT integration is likely to be difficult when each school has only one computer laboratory, when more than 100 learners need to use computers (DBE 2012).

The non-availability of ICT resources influenced eight of the 17 (47%) to advocate for learners to be allowed to use their cell phones for learning (*Interview, 22/09/17 & 23/09/2017*).

> *"I decided to start asking learners to bring their cell phones to use them. And I get blown away by the fact that some of them own even more expensive cell phones than I own" (Interview, T10, 22/09/17).*

> *"I am now able to share small content with my learners. Because their phones go flat easily I arrive every day at 7:00 and share content with them before their batteries go" (Interview, T38, 22/09/17).*

The non-availability of computers or tablets or data projectors in some schools frustrated these teachers and delayed the progress of ICT integration. These teachers self-reported that the non-availability of resources made them resort back to the traditional methods of teaching Physical Sciences *(Interview, 22/09/17 & 23/09/2017)*. Mbatha (2015) also pointed out that the non-availability of ICT resources can influence teachers to resort to traditional methods of teaching. The use of traditional methods in South African schools is a proven factor that deters the use of technology (Msila 2015; Chigona & Chigona 2010; Mdlongwa 2012). I assume that the use of traditional methods of teaching does not imply that they are not good enough for teaching. It rather suggests that where there is willingness from teachers to use ICT for teaching but are distracted by the non-availability of ICT resources, the use of traditional methods is likely to hold them back from integrating ICT.

Despite the non-availability of ICT resources in most of the schools in this study, there are some schools with ICT resources. Seven of 17 (41%) of the teachers self-reported that computers were available at their schools. Three of these teachers were at a Mathematics, Science, and Technology (MST) school. These are schools that benefit from the MST grant and are provided with resources. A teacher from an MST grant school said that at his school there is a laboratory that has an interactive board and a data projector, and he also has access to two laptops (his personal laptop and school's laptop) *(Interview, T40, 22/09/17 & 23/09/2017)*. Another teacher reported having both an MST and a "Smart School Project" laptop. Smart School Project schools are provided with computers and laptops for each teacher and learner *(Interview, T43, 22/09/17 & 23/09/2017)*. The availability of ICT resources impacted positively on the use of technology during the teaching of Physical Sciences for T40 and T43, and they were able to finish the curriculum ahead of schedule *(Interview, 22/09/17 & 23/09/2017)*.

6.3.2.2 Accessibility of ICT resources

Accessibility refers to when teachers and learners can access the right type and number of ICT resources in areas where they can use them, to ensure that ICT is used during teaching and learning (Wilson-Strydom & Thomson 2005; Hew & Brush, 2007). The quantitative findings in this study revealed that most of the teachers in this study did not have easy access to computers, data projectors, smartboards and tablets, while their learners could not access computers, tablets, and cell phones during the teaching and learning of Physical Sciences before and after the training as discussed in paragraph 6.2.4. The interviews revealed that some of the teachers could access the ICT resources during the teaching of Physical Sciences, while others could not.

Two of the 17 (12%) teachers interviewed in this study had access to personal Wi-Fi and the rest of the teachers relied on their school's Wi-Fi, which they could not access most of the time *(Interview, 22&23/09/17)*. T40 expressed how lucky he was to work at a well-resourced school with access to Wi-Fi:

> *"Luckily I am from a well-resourced school. I have a smartboard, a laptop and I can access Wi-Fi at any time of the day at my school. Even learners can access Wi-Fi. I always download information and videos that help me to understand any topic in Physical Sciences. Compared to what I heard from colleagues I am very fortunate" (Interview, T40, 23/09/17).*

T34 did not have the same experience regarding access to Wi-Fi at her school:

> *"Unfortunately, at my school there is Wi-Fi, but I cannot access it. Only school management team members have the password and can access it. I tried that I be allowed to access it since I want to download information I learned in this programme, but I did not succeed. And this led me to be frustrated I don't know how many times as it was challenging to download the valuable information that will help me to teach" (Interview, T34, 22/09/17).*

The more devastating experience is with T38, who is from a school located in a rural area:

> "*Unlike T40 where there is Wi-Fi and can access it, in my school there is no Wi-Fi and there is only one computer which is used by our clerk. I must also say this*

made it difficult for me to implement what I learned, and I am nicely frustrated and demotivated" (Interview, T38, 22/09/17).

Problems with connectivity left most teachers frustrated and demotivated, and delayed progress regarding the use of ICT, despite them being willing to use ICT during their teaching of Physical Sciences. Unreliable and limited connectivity in South African schools is still a significant obstacle towards ICT integration, even though some schools have been provided with internet connectivity through various projects (Mweli 2013).

The non-accessibility of ICT resources can lead to the non-usage of ICT during the teaching of Physical Sciences. A teacher expressed how he could not implement the programme due to non-accessibility:

"There are computers brought to my school and have not been used and gathering dust. I was denied access to use them such that it was difficult for me to use them to teach Physical Sciences" (Interview, T11, 23/09/17).

The non-accessibility to ICT resources can also lead to low motivation, and teachers feeling as if they had failed to achieve their teaching objectives. This is what one teacher said:

"I do not have access to the computers, but I do have my laptop. I use a laptop for my learners to watch videos. I download the videos from YouTube. I have large classes (in terms of number of learners), the use of videos at the moment it is not useful. At the moment the situation is making me less motivated" (Interview, T12, 22/09/17).

The non-accessibility to ICT resources can lead to unhealthy competition and interpersonal conflicts at school. This is the experience of T25:

"There are two data projectors in my school and access to use them frequently is a challenge as other teachers are using them as well. This situation has led to us competing to grab the data projector before others could do. This has led to us fighting all the time especially the one who makes sure that he/she grab it first all the time" (Interview, T25, 25/09/17).

Clearly the non-accessibility to ICT resources impacted on how teachers used ICT in terms of non-usage of ICT during teaching, low teacher motivation and the inability to achieve lesson objectives, and unhealthy competition and conflict among teachers. Access to ICT resources is a crucial prerequisite for ICT to be integrated in teaching and learning. Schools with limited access to ICT resources will have limited chances to integrate ICT (Drossel, Eickelmann & Gerick 2016).

I believe that for ICT integration to be effective and successful in South African schools, learners and teachers should have access to ICT resources whenever they want to use them. However, Wilson-Strydom and Thomson (2005) point out that it is not guaranteed that when teachers and learners have access to ICT resources, ICT usage will be maximised in teaching and learning. Access to ICT resources is clearly a necessary, but insufficient, criterion for ICT uptake. An additional criterion is teacher competence to use ICTs within their lessons, which is what this professional development opportunity aimed at improving.

This view is supported by instances in the data where teachers who had access to ICT resources at their school applied what they had learnt in the programme to integrate ICT into their teaching of Physical Sciences. For instance, T43 expressed how access to ICT resources and the use of ICT has led him to achieve recognition of good performance in Physical Sciences by the Free State Department of Education:

> *"I do have access to the computers and tablets. I have my own tablet from the smart project, and a laptop. I have access to computers/laptops. Like I said my school is well resourced (my school had tablets since 2015). I have been using Edukite, programme to teach my learners. I use the programme for personal growth in the subject and for teaching my learners. My school is a recognised best performing school in Physical Sciences by the province" (Interview, T43, 22/09/17).*

6.3.2.3 Policies controlling access to other ICT resources

The information in the literature on how technology integration can be achieved is abundant, but little is mentioned about the role of a school's ICT policy regarding ICT integration. One of the conditions for ICT to be successfully integrated is "having a shared vision and ICT policy plan" (Hew & Brush 2007).

A school-based ICT policy plan is a detailed document consisting of a variety of operational and strategic points regarding how technology can be integrated in learning and teaching. Some of the critical elements to be included in such a policy are how to use technology to teach, how ICT resources could be equally allocated to staff members, and how the resources can be accessed regularly and effectively by all "end-users (learners, teachers, managers, and administrators)" (Department of Education 2004, p. 22). None of the interviewed teachers self-reported that such a school-based ICT policy plan was available in their schools. The non-availability of such a policy resulted in unfair resource allocation. Subjects such as Mathematics and Computer Applications Technology were allocated ICT resources, while no allocation was made for Physical Sciences *(Interview, 22/09/17 & 23/09/2017*). As a result, in most instances Physical Sciences teachers and learners were denied access to the available ICT resources meant for Mathematics and CAT *(Interview, 22/09/17 & 23/09/2017*). T1 who said:

> ***"****People would want to own equipment in schools, to say if this is the Science department's material then other people are not allowed to use the equipment. They feel it belongs to them. Entitlement is very toxic in our school system. People can learn to share. I am a victim at my school, I ended up using pen and paper, chalk and chalkboard because of this toxic environment of people owning equipment and not wanting to borrow. For example, Mathematics tablets, I would ask to use them but be denied access as I am told they are meant for Mathematics. That created conflict until I ended up not going to the Maths Centre and stick to my laptop" (Interview, T1, 22/09/17).*

The tension and conflict created by the perceived ownership of ICT resources as experienced by some teachers in some schools is expressed by T25 when he said:

> *"At my school, there is a computer applications technology class, and the lady owns that class. We have an Internet Broadcast Programme; she also controls the Internet Broadcast Programme. When I am in the computer applications technology class with my learners there are a lot of don't do this and that, tell your learners not to touch this and that. She comes with a lot of excuses so that I am not able to use the class. Unless I become demanding it is only when I can use*

the computer applications technology classroom. Such challenges prohibit me to implement the programme the way I wish" (Interview, T25, 22/09/17).

Clearly the unfair allocation of resources not only resulted in conflict and tension, but also delayed the implementation of what was learned in the programme. Rather than to be frustrated and feel helpless, eight of the 17 Physical Sciences teachers resorted to telling their learners to bring their cell phones to be used during the teaching and learning of Physical Sciences. This option of using cell phones during school time is against the policies of most schools. T53 said:

"In my school learners are not allowed to come with their phones. All of them are not able to be engaged every day" (Interview, T53, 23/09/17).

Teachers in a study by Mathipa (2015) also wanted to use cell phones as an alternative to computers, but the policy of the school would not permit the use of cell phones. In my study, T12 was given permission by her principal that her learners were allowed to use their cellular phones during Physical Sciences lessons. Unfortunately, this is what she experienced:

"It is the case in my school however my learners only use the phones in the Physical Sciences class, unfortunately the following day other teachers would have taken their phones as they are not allowed to bring them at school. This meant that my whole planned lesson will be disturbed, and I will be nicely frustrated. That is my challenge" (Interview, T12, 23/09/17).

This school-related policy factor, i.e. non-allowance of learners to use cell phones especially where there are no other ICT resources, affects how ICT is integrated in the classroom (Tondeur et al. 2008), as was the case in this study. I believe that mobile phones can be used for educational purposes and in support of certain teaching and learning activities, particularly in schools without sufficient information and communication resources. Therefore, I feel that such schools should consider amending their policy regarding the use of cell phones by learners during the teaching of Physical Sciences.

Gülbahar (2007) argues that one way to solve the challenges encountered during the process of ICT integration is to have a school ICT policy. In schools where there is a school ICT policy, which emphasises commonly understood goals, ICT can be consistently used by teachers to teach (Tondeur et al. 2008). Tondeur et al., (2008), also argue that a school ICT policy is not a necessity since it may prohibit individual teachers' creativity regarding the use of ICT.

6.3.2.4 Infrastructure and learner enrolment

Some of the ICT projects which have failed in the South African education context did so due to inadequate or unreliable infrastructure. Inadequate or unreliable infrastructure is one of the reasons that South African teachers are not able to incorporate ICT into their teaching (Ford & Botha 2010; Langat 2015). The South African president also raised concerns that this inadequacy of ICT infrastructure is one of the contributing factors that the incorporation of technology into teaching and learning is slow in South Africa (Engineering News 2015).

This study revealed that there is no proper infrastructure in most schools to support the integration of technology. The three teachers in the interview sample who were from MST schools were an exception in this regard. For example, in paragraphs 6.3.2.1 and 6.3.2.2, mention was made that there is only one, or a limited number of computers or tablets or data projectors in most schools, and connectivity is also a challenge in most schools. For instance, as previously referenced in paragraph 6.3.2.1 and 6.3.2.2:

> ***"****We do have 20 laptops in my school. We just recently received tablets, unfortunately, we did not have chargers and we could not use them and apparently, they were for mathematics, and I could not access them" (Interview, T11, 23/09/17).*

> "*Unlike T40 where there is Wi-Fi and cannot access it, in my school there is no Wi-Fi and there is only one computer which is used by our clerk. I must also say this made it difficult for me to implement what I learned, and I am nicely frustrated and demotivated" (Interview, T38, 22/09/17).*

The study further revealed that in some schools there are computer laboratories with no computers, and some computer laboratories cannot accommodate more than 20 learners since there are 20 or less computers. Where there are no computer laboratories, or laboratories cannot accommodate more than 20 learners, learners are allocated specific days on which they can go to the computer laboratory, as explained by T25:

> *"I have big learner numbers in my school. On average my learner numbers is 45. This makes it difficult for me to use computer laboratory. I therefore have to divide learners into groups for them to be able to be in the laboratory to use computers. Same topic is taught several times, this contributes to the slow place to cover the curriculum" (Interview, T25, 23/09/17).*

The delays due to infrastructure issues discourage some teachers from using technology to teach in this study. The practice in schools with high enrolment numbers is usually that the computer laboratory is used on a first-come-first-served basis, and this causes a further delay in teaching *(Interview, 22/09/17 & 23/09/2017)*. Mweli (2013) points out that the shortage of computers and computer laboratories is a barrier that prevents the successful utilisation of technology, as was found to be the case for some of the teachers in this study. For example, as previously referenced in paragraph 6.3.2.1:

> *"In my school, we do have only one computer lab, unfortunately, it is only for CAT learners" (Interview, T25, 23/09/17).*

When the number of learners in a class is far more than the number of computers available, teachers, as in T25's case, coped with this situation by using a rotation roster for the computer laboratory, and thus learners and teachers share the available computers. However, this situation is not conducive to the use of technology. In addition, teachers are likely to find it more difficult to manage learners when the computer laboratory is full. Teachers who are not prepared to make efforts and arrangements regarding the sharing of resources, distance themselves from adopting the use of technology (Korte & Hüsing 2007).

In research conducted by Mathipa and Mukhari (2014), teachers expressed a concern that the computers available for their use were far fewer than the number of learners in a class due to overcrowding. Therefore, it was not possible for each learner to use his or her own computer to learn. Instead, learners had to be grouped to share one computer at a time. In such situations, some learners do not engage fully, and take a step back and allow themselves to be led by active learners in their educational activities. The high learner-computer ratio is an injustice to education, says Mweli (2013).

Teachers can be adequately trained and be willing to pass on the gained knowledge and skills to their learners, as seems largely to have been the case in this study, but if the ICT resources they have access to are inadequate, they will be hindered from integrating ICT into their teaching (Ngwu 2014). For example:

> "*We have a computer center, but all computers are not working. They were taken for repair and never came back. As it is I cannot fully engage my learners the way I am taught at the programme, which is the way we are engaged at the programme*" *(Interview, T11, 23/09/17).*

6.3.2.5 Theft

Theft is a negative factor that hinders the utilisation of ICT (Mungai 2011). This meaningful factor has the potential to destabilise education in many South African schools (Mathipa & Mukhari 2014). In a study by Mathipa and Mukhari (2014), most teachers in their study reported that their computer laboratories had been burgled on several occasions, and that laptops, tablets, printers, and computers had been stolen. The teachers in Mathipa and Mukhari's study (2014) also reported that a flat-screen TV was stolen in one high school, and it was impossible for learners to watch the planned enrichment lessons. The teachers in the study by Mbatha (2015) also reported several stolen computers at their schools.

Teachers in this study also reported cases of theft in their schools. T25 expressed his fears regarding theft:

> *"The other thing in my school and in the area where my school is located is that theft is very high. I am afraid to ask learners to bring cell phones. This could be something that makes learners not to bring cell phones even if I ask them to" (Interview, T25, 23/09/17).*

Clearly, theft negatively affected how often T25 wanted to use technology in his teaching, and he was frustrated. This is how he expressed his emotions:

> *"Based on my challenges, one computer lab, high learner numbers and high theft rate, my implementation rate of using technology to teach is very slow and most of the time frustrating me. This is all I can say. So, for me I did what I could in this situation" (Interview, T25, 23/09/17).*

6.3.2.6 Support and maintenance

Peer, administrative and technological support are some of the types of support needed to enforce successful integration of ICT (Ertmer et al. 2012). The majority of teachers need support to overcome technical challenges (Hew & Brush 2007; Ertmer et al. 2012)

Altawallbeh et al. (2019) noted that teachers need to be supported in order to change their perceptions of the control they can exert over their behaviour with regards to ICT integration. Four of the teachers interviewed in this study indicated that they had been given professional support by their principals to access ICT resources. For example, as previously mentioned, T43 did received support from her school's management team:

> *"I do have access to the computers and tablets. I have my own tablet from the smart project, and a laptop. I have access to computers/laptops. Like I said my school is well resourced (my school had tablets since 2015). I have been using Edukite, programme to teach my learners. I use the programme for personal growth in the subject and for teaching my learners. My school is a recognised best performing school in Physical Sciences by the province" (Interview, T43, 22/09/17).*

There was no professional support offered by the school management team in T34's case. She was not allowed to use tablets during the Physical Sciences period:

> *"After I transferred what was in the tablet to computers in the media centre so that everyone can be able to do what I want to do with them, and we do it together. The School Management Team denied me access to use the media center during my teaching period" (Interview, T34, 22/09/17).*

The results of the studies by Bingimlas (2009), Afshari et al. (2009) and Levin and Wadmany (2008), revealed that the teachers in their respective studies successfully changed how they used technology during teaching when they were provided with professional support. Altawallbeh et al. (2019) argue that for high perceived behavioural control to be achieved, professional support at school level is required. The professional learning opportunity described in this study appears to have been effective in providing at least some of the participants the professional support that they needed to not only to know about ICT use, but also how to effectively use different programmes to teach Physical Sciences *(Interview, 22&23/09/17).*

Malfunctioning computers and failure to connect to the internet are some of the issues that can be ironed out by technical support. The smooth delivery of a classroom lesson or its natural flow may be hampered due to a lack of technical support (Sicilia 2005 cited by Bingimlas 2009). Majority of teachers in this study reported that the absence of technical support is likely to delay the delivery of curriculum coverage *(Interview, 22/09/17 & 23/09/2017)*.

The lack of maintenance and updating of computers were self-reported as a challenge in most schools in this study. Schools would function for weeks and months without any working computers while waiting for the district technical support team to repair them *(Interview, 22/09/17 & 23/09/2017)*. T15 said:

> *"There are computers at my school, but all computers have viruses and cannot be used. Similarly, most interactive boards are not working and there are no efforts from the school management team to fix them" (Interview, T15, 22/09/2017)*.

When teachers are given the technical support they need, they will not have to deal with technical problems, but will be able to focus on their teaching to finish the curriculum as expected (Chen 2008; Goktas, Gedik & Baydas 2013; Law & Chow 2008).

6.4 PRACTICES DEMONSTRATED BY TEACHERS IN THEIR USE OF ICT

Assertion 3: Most teachers used technology to enhance teacher-centred practices at substitution and augmentation levels. A few teachers used technology to enhance learner-centred practices at modification and redefinition levels.

The lesson descriptions and reflections of 38 teachers involved in this programme, presented in their final assessment tasks, were analysed. As seen in Table 6.8 below, 20 (52%) and 12 (31.6%) of these 38 teachers used ICT to enhance teacher-centred practices at substitution and augmentation levels respectively. Teacher-centred practices are usually related to behaviourism (Deng et al. 2014), and highlight moral standards, subject matter, and discipline (Mayer 2003). Learning occurs in a structured environment, and the teacher supervises the process of learning acquisition, serves as an expert, and acts as an authority (Mayer 2003). The teacher is the supreme information evaluator and giver (Ahmed 2013).

In both substitution and augmentation, ICT was used to represent information. According to Hokanson and Hooper (2000), when technology is merely used to represent information in another medium, this is referred to as representational use of ICT. Even if the technology is used within a lesson, its motive is to “re-present” information, not to produce or create completely new information and transform tasks in a manner which affords learners greater autonomy.

It must be noted that teachers may restrict the use of technology to representational usage when their pedagogical beliefs are influenced by behaviourist theories of learning, and their epistemological assumptions are described by the objectivist beliefs of knowledge (Wilson-Strydom & Thomson 2005). For example, a teacher can believe that making a beautiful front cover using an attractive font and page border, and just typing a lesson plan, can be defined as “integration”. Therefore, what teachers believe represents effective learning and good teaching is influenced by their perceptions about how they use technology, and their actions towards developing and changing their teaching methods (Ertmer et al. 2015). Some authors have argued that in the context of the developing world, such as exists in at least the lower quintiles of South African schools, teacher-centred practices are understandable and, possibly, even optimal within the constraints imposed by the context (see, for example Tabulawa 2013; Guthrie 2018; Stott 2018). It is therefore not at all surprising that most of the teachers in this study used ICT in teacher-centred ways.

What is surprising, is that a fair number of teachers, some of whom even taught in low quintile schools, were able to use technology in learner-centred ways. This can be seen in Table 6.8. Here it is illustrated that three (7.9%) and another three (7.9%) of the 38 teachers whose lesson descriptions and reflections were analysed, used ICT to enhance learner-centred practices at the modification and redefinition levels respectively. When a teacher focuses on individual learner interests and needs, he or she is likely to adopt learner-centred practices (Mayer 2003). Learner-centred practices are associated with constructivism (Deng et al. 2014). Learner-centred practices are grounded in learners taking ownership of their own learning, and making important value judgments and decisions about the relevance of the methods of teaching and content to their own lives. This gives them a degree of autonomy, which improves the likelihood that they will become self-directed in their learning (Brown 2008). The teacher assumes the role of guide or facilitator, who assists learners to accomplish their ambitions (Ahmed 2013).

According to Hockly (2013), the true potential of learning is likely to be fully realised only at the modification and redefinition levels, even though positive benefits of learning in the substitution and augmentation levels may be visible. In both the modification and redefinition level, technology is not only used to view multimedia presentations or as a word processing function, but in ways that enable learners to create knowledge. Hokanson and Hooper (2000) argue that technology used in this way is generative and not representational. The concept of “generative use” is underpinned by a Piagetian cognitive constructivist view of learning and knowledge. This view assumes that knowledge is a process of individuals constructing knowledge, and not a product that can be transmitted from one person to another. The notion of “generative use” can be expanded to a Vygotskian socio-constructivist view of learning and knowledge. This view assumes that knowledge is a process of negotiation of meaning in a specific context, which cannot be limited to an individual’s view of it (Wilson-Strydom & Thomson 2005). Teachers are likely to extend the use of technology to generative uses if their pedagogical practice are informed by cognitive constructivist theories of learning, and their epistemological assumptions are defined by constructivist beliefs of knowledge (Wilson-Strydom & Thomson 2005).

Table 6-8: Classification of teachers' usage of ICT

SAMR level	Explanation (what this level entails)	Applications observed, in the final assessment task.	How these applications were used.	Justification of why this constitutes classification at this level	Number of final assessment task examples of this type	Teacher who used the assessment task at this level	Reference descriptive example
Substitution	Traditional teaching is directly substituted by use of technology (Puentedura 2014).	Video	The teacher used a video to teach the lesson.	The video substituted the teacher.	18	T1, T10, T11, T15, T2, T3, T8, T20, T21, T27, T28, T29, T30, T31, T35, T36, T41, T52	
		PhET simulation	The teacher used a PhET simulation to demonstrate the relationship between electric current and potential difference.	The PhET simulation substituted physical electric circuit equipment.	1	T23	
		PowerPoint	The teacher used PowerPoint to teach learners how to write balanced chemical reactions.	PowerPoint substituted a chalkboard. No visuals were used that could not have been presented on a chalkboard.	1	T22	5.3.3.2
Augmentation	Interactive digital enhancements and elements such as comments, hyperlinks, and multimedia are integrated to the lesson. (Terada 2020).	PowerPoint and PhET simulation	The teacher used PowerPoint to teach on electric circuits, and then demonstrated the use of a PhET simulation. Learners were required to answer questions about this.	The teachers were able to present visuals that could not have been drawn on the chalkboard.	7	T12, T43, T25, T26, T44, T47, T49	
		Video, PhET simulation and quizzes	The teacher used a video to teach about electric circuits, and then demonstrated the	The teachers were able to present visuals which could not have been	3	T23, T45, T14,	

			use of a PhET simulation. Learners were required to answer self-marking electronic quizzes about the topic.	drawn on the chalkboard. The self-marking nature of the quizzes augmented the questioning process by giving immediate feedback.			
		Kahoot	Kahoot was used as a quiz, and the lesson was conducted as a competition.	Kahoot augments a traditional quiz competition in offering automated features such as immediate feedback.	1	T13	
		PhET simulation	The learners were required to determine the effect of resistance on the brightness of the bulbs in a series and parallel electric circuit using PhET. The teacher first demonstrated how to use the Phet simulation. One learner was nominated to manipulate the PhET simulation, while the other learners were noting observations and completing the worksheet.	The PhET simulation augmented physical electric circuit equipment by enabling the learners to conduct a self-directed exploratory investigation without fear of damage to equipment, such as short-circuiting batteries and fusing ammeters.	1	T53	5.3.4.2
Modification	Technology is used to transform tasks in a manner which enhances learner	Interactive PowerPoint PhET simulation	Both teachers used PowerPoint to teach electromagnetic induction, after which the learners worked individually on school tablets to investigate	Learners used the simulation hands-on in an autonomous and self-directed manner.	2	T51 and T32	

	autonomy and encourages self-direction (Brown 2015).		and formulate Faraday's law on their own.				
		Video PhET simulation	T4 used a video and open inquiry through Phet simulation. She used a flipped classroom approach. The learners self-studied the topic for homework, using the video. The learners then worked individually on tablets with a Phet simulation to apply what they had learnt in the video to derive Faraday's Law.	In a flipped classroom, technology enables the learner to self-study, which in turn enables alteration of the roles of the learner and the teacher in comparison to the traditional classroom.	1	T4	
Redefinition	Tasks that would be impossible without the technology (Hilton 2016).	Direct measurement videos	Learners used a direct measurement video to take measurements of displacement and time, and from these calculate the speed of a ping-pong ball and a roller coaster. Direct measurement videos are high quality, short videos of real events that allow learners to make accurate measurements from recorded investigations.	The high speed at which the motions occur makes it impossible to measure these phenomena without the use of high-speed photography and the stop-motion playback feature. Additionally, learners would not have access to the high-quality equipment and precise measuring tools, which this technology provides, in a standard school laboratory.	2	T33 and T46	
		Interactive	The teacher used	This provides the	1	T24	5.3.5.2

		PowerPoint and Plickers	interactive PowerPoint and the Plickers system to teach the mole concept of stoichiometry. With Plickers, the teacher uses a mobile application to scan coded cards that learners hold up at a particular orientation to indicate their answer.	learner with the confidence to answer, without their peers knowing how they answered. It allows the teacher to see whether, and how, each learner has answered, and enables the teacher to instantly display graphical feedback of the collective response of the class. These pedagogically valuable features are impossible without the use of technology.			

6.5 TEACHERS' PERCEPTIONS REGARDING HOW THE USE OF ICT AFFECT THE QUALITY OF TEACHING AND LEARNING

Assertion 4: Most teachers perceived that integration of ICT in the teaching of Physical Sciences is likely to result in improved: (a) ways of teaching and learning, (b) learner motivation and participation, (c) teacher professional growth, (d) learner independence and collaboration, and (e) improved learner performance.

6.5.1 Better ways of teaching and learning

Assertion 4.1: Most teachers perceived that the use of ICT leads to better ways of teaching and learning.

In their research Tella, Tella, Toyobo, Adika and Adeyinka (2007) reported that the use of technology made Nigerian teachers' lessons more enjoyable, motivating, interesting, fun, diverse and easier for both the teachers and their learners. This is consistent with T24's report on his learners' experience with his integration of technology during the teaching and learning of Physical Sciences:

> *"I never thought I can teach using competitions. What I noticed is that my learners are enjoying, excited, participative during the lessons. I also noticed they are glad that I am doing something extra from chalk and board. Because they learnt a lot after I changed quite a number of things in my teaching. The Grade 9's now, as there are those that are struggling and those that are fast. As I try to explain to the ones that are struggling, the ones that are fast will literally say give us the work for tomorrow. Can you give us something that is ahead? This makes my work easier as it is their initiative and I would give them a lot of work to do, they always complete the work I give them. I now see motivated learners in my class. And that will be Mathematics and not Science" (Interview, T24, 23/09/2017).*

This report suggests that T24's altered teaching style, which accompanied his integration of ICT into his lessons, enhanced the autonomy and self-direction of his learners. This finding is further supported by reports, such as given by T23, on the effect that the use of simulations had on providing learners with the opportunity to actively construct knowledge rather than merely being passive receivers of knowledge:

"Before I joined the programme, I would do experiments for the learners and discover what needed to be discovered for them. Learners would only answer the worksheet at the end of the experiment. After I joined the programme, I don't do experiments for the learners anymore. I taught my learners to use PhET simulations for and to discover many concepts for themselves. My role is to just clear where they do not understand. This for me is making teaching easy" (Interview, T23, 23/09/17).

This corresponds with literature suggesting that the use of ICT can bring about a change in a teacher's role to be that of a facilitator, coach, co-learner, knowledge navigator, and a collaborator, who gives learners responsibilities and options for their learning. This is opposed to the more traditional view of a teacher as the figure at the centre of learning, responsible for directing and controlling all processes of learning (Brown 2006; Ul Amin 2013; Kler 2014; SAIDE 2005).

Mukhari (2016) and Vandeyar (2013) assert that when ICT is used, learners with different learning styles and needs are better accommodated. Consistent with this, T25 stated that three of her learners reported enhanced learning due to the teacher's use of visuals in PowerPoint. It is possible to project images to support teaching and learning that would have been impossible without ICT:

"After three weeks of using PowerPoint, and other technologies, three learners who used to not participate in my classes approached me to tell that they are now enjoying my lessons. It is not easy to forget what they saw. I could literally see the excitement in their eyes" (Interview, T25, 23/09/2017).

T51 also expressed how the use of technology helped her learners by improving visualisation:

"I have had a group where majority of the group were visual learners and me trying to explain and do it on the board was just not working, so (yah) I think it has made teaching Physical Sciences way better for these learners" (Interview, T51, 22/09/2017).

Shan Fu (2013) and Vandeyar (2013) found that the use of ICT has a beneficial effect on educational and instructional goals such as learner discipline and attendance.

Learner attendance and well-controlled classes maximise the opportunity for learning to take place. Fourteen of the 17 (82.4%) teachers who were interviewed in this study indicated that learner discipline and attendance have improved in their classes since they started using ICT in their lessons. These teachers reported that instead of their learners being noisy and avoiding Physical Sciences classes, they completed their assigned tasks and even worked beyond what they had been instructed to do. Peer learning was also observed to take place. These 14 out pf 17 teachers *(Interviews 22/09/17 and 23/09/17)* indicated an improvement in their classroom discipline thanks to their engagement in this professional development opportunity: They were *T1, T4, T10, T11, T12, T15, T22, T23, T24, T40, T43, T45, T51* and *T53.*

6.5.2 Learner motivation and participation

Assertion 4.2: Most teachers perceived that the use of ICT improved their learner motivation and participation.

Teachers' experiences in a study conducted by Vandeyar (2013) suggests several benefits when technology is used during teaching and learning, of which the main two are enhanced motivation and participation. In this study T24 expressed how the use of ICT has enhanced learner participation in his class:

> *"I had extra classes and you would find that in the afternoon these kids are just tired, and they just want to leave. This programme exposed me to how do I get learners to be more involved even if they want to leave. So I saw the opportunity because the programme was talking about ICT and a little bit of less chalk board and more of technology which is what these kids like. Whether it is in the afternoon or in the morning, they would be 100% involved" (Interview, T24, 23/09/17).*

Not only did learner participation improve in terms of extra class attendance, but also during the normal Physical Sciences classes. He believed that he achieved this improved participation by posting motivating messages on the website he created as a direct outcome of this professional learning opportunity. One of his daily goals was to make the teaching and learning of Physical Sciences fun, and to ensure that learners have fun during the learning process. He reported that more Grade 9 learners enrolled to take Physical Sciences in Grade 10 in the next year than had been the case in previous years, which he attributed to his new approach *(Interview, T24, 23/09/17)*.

T24 reported that the use of Plickers improved learner participation in class. He reported the case of one of his learners as an example. Previously this learner had not done his homework and had never asked or answered any questions in class or participated in class in any visible manner. Since T24's use of Plickers, this learner had become an active participant and one of the best performing learners *(Interview, T24, 23/09/17)*.

6.5.3 Teacher professional growth

Assertion 4.3: Most teachers perceived that the use of ICT influences teacher professional growth.

In a study conducted by Vandeyar (2013), teachers' professional identity, beliefs, and classroom practices gave the impression that there are multiple benefits for learning when technology is used during teaching. Some teachers in this study openly declared their positive attitudes and beliefs regarding the influence of the use of ICT in teaching and learning (*Observations, February to September 2017*). The positive attitudes regarding the use of ICT were also expressed by most interviewed teachers in this study. These teachers expressed how they had professionally matured in their career due to their enrolment in the SLP, and many of their prior teaching practises had changed as a result *(Interview, 22&23/09/17)*.

Some teachers reported that they no longer limited themselves to the four walls of the classroom. They had begun to think out of the box. For example, T43 wanted to demonstrate precipitation reactions to his Grade 10 learners. He googled the precipitation reaction and found a relevant video that met his lesson objectives. T43 remarked about how his persistence has matured. Before he joined the programme, he would have given up easily and would not even have pursued to download the reaction *(Interview, T43, 22/09/17)*.

Fourteen (82.4%) of the 17 interviewed teachers self-reported improved confidence in their teaching of Physical Sciences. This confidence was brought about by the fact that they now allocated themselves enough time for lesson preparation and lesson planning using technology. As a result, their lessons were more organised than before they joined the SLP *(Interview T1, T4, T10, T11, T12, T15, T22, T23, T24, T40, T43, T45, T51 & T53, 22/09/17 & 23/09/17)*.

Before they joined the programme, eight (47%) of the 17 interviewed teachers in this study understood the focus of teaching to be on teaching the content. They did not pay much attention to the relevant pedagogical methods that would enable them to teach the specific content. This programme taught them that even if a teacher knows the content, it is equally crucial that the teacher must pay attention to the pedagogy used, to ensure the effective teaching of the content *(Interview, T4, T10, T11, T15, T24, T40, T43 & T45, 22/09/17 & 23/09/17)*.

According to seven (41.2%) of the 17 interviewed teachers, the session in which they designed and evaluated their own PowerPoint presentations helped them to become more critical thinkers. These teachers indicated that they were no longer easily impressed by glamourous PowerPoint presentations with distracting features that did not enhance the message. Instead, they now critiqued other people's PowerPoint presentations, especially when they attended workshops or conferences *(Interview, T1, T10, T24, T40, T45, T51 & T53, 22/09/17 & 23/09/17)*. Additionally, they have become self-critical, for example:

> *"Before this programme I would type a test and print, only to realise that the very last question the marks are not aligned well, and I would say that is nothing and I would leave it there. After the programme I will not allow that mistake to happen, if my facilitator can see this test, she will not be proud of me as a student, let me retype and do it better. Because I am proud of my work, then I put my name in the test. And I feel proud of my own work. I like it when I study and go back to implement the knowledge learned. It has developed me and has made me very critical" (Interview, T51 22/09/17).*

Further, 14 (82.4%) of the 17 interviewed teachers reported that the programme helped them to use ICT more frequently during their teaching of Physical Sciences. Some teachers indicated that they now use ICT daily, with others using it three or four times a week. These teachers reported that this higher frequency of use of ICT enabled them to cover the curriculum within the set target dates as communicated by the district. This promoted collaboration with other teachers not teaching Physical Sciences *(Interview, T1, T4, T10, T11, T12, T15, T22, T23, T24, T40, T43, T45, T51 & T53, 22/09/17 & 23/09/17)*.

6.5.4 Learner independence and collaboration

Assertion 4.4: Most teachers perceived that the use of ICT promotes learner independence and collaboration.

Mdlongwa (2012) believes that increased collaboration improved knowledge and skills, increased motivation, increased active participation or creativity, and increased responsibility and self-esteem are some of the benefits for learners when ICT is implemented properly. The use of technology enables high performance in science and Mathematics, and the acquisition of social and digital skills are required in the learners' current worlds and future society where technology plays a critical role (Starkey 2011, Van Rij & Warrigton 2010; Shin et al. 2012).

The findings in this study have shown that independent learning and collaboration amongst learners were promoted by using technology. For example, 11 (64.7%) of the 17 interviewed teachers reported that some of their learners studied on their own using videos, completed tasks on their own using quizzes, and would go beyond what they were tasked to do. They also helped their struggling peers. Collaboration amongst learners promoted the participation of learners, including those learners who were previously known to shy away from asking questions and participating in class activities *(Interview, T4, T10, T12, T15, T22, T23, T24, T40, T45, T51 & T53 22/09/17 & 23/09/17)*.

6.5.5 Improved learner performance

Assertion 4.5: Some teachers perceived that the use of ICT improves learner performance.

Eight (47%) of the 17 interviewed teachers self-reported improved learner performance in their Grade 10 Physical Sciences classes as a result of their altered pedagogy due to participation in the programme *(Interview, 22/9/17 & 23/09/17)*. According to the model of teacher change by Guskey (2002) as discussed in paragraph 2.7.1.1, the model asserts that it is only after there has been improved learner performance that teachers' beliefs and attitude can significantly change. The improved performance of learners likely resulted from the teachers' changes in teaching practice. These include changes in teaching approaches and the use of new ICT materials (as discussed in sections 6.5.1 & 6.5.3). Those teachers who perceived a positive change in learner performance to be associated with these changes to their teaching practices, were likely to have experienced enhanced motivation to continue to use ICT during the teaching of Physical Sciences *(Interview, T4, T12, T22, T23, T24, T45, T51 & T53, 22/09/17 & 23/09/17)*.

This is consistent with Ul Amin (2013) and Fuchs and Woessman's findings (2004) that the appropriate use of technology has a substantial positive effect on both learners' performance and attitude. In contrast, numerous other studies have shown no relationship between learner achievement and the use of technology (Banerjee, Cole, Duflo & Linden 2007; Machin, McNally & Silva 2007; Erdogdu & Erdogdu 2015; Leuven, Lindahl, Oosterbeek, & Webbink 2007; Skryabin, Zhang, Liu & Zhang 2015; Gil-Flores, Rodríguez-Santero & Rodríguez-Santero 2017).

6.6 ISSUES THAT AROSE DURING THE PROFESSIONAL DEVELOPMENT OPPORTUNITY

Assertion 5: Issues which arose during the programme included difficulties with (a) being presented with a large amount of new information within a limited time, (b) technical difficulties such as poor connectivity and the complexity of the update procedure, (c) the expectation, held by some participants with very low technological skills, that the programme would focus on the development of these skills, rather than on technological knowledge and PCK. Some teachers responded to these difficulties by becoming frustrated, while others become more self-directed in their learning. The first iteration of this programme, reported on here, exposed unanticipated challenges which later iterations would benefit from in hindsight. It also exposed the need for providing different programmes for teachers of different baseline levels of ICT skill.

6.6.1 Too much information given within a limited time

Fourteen of the 17 interviewed participants expressed the concern that too much information was given within a limited time. The teachers dealt differently with this concern. As previously mentioned, T22 expressed her frustration this way:

> *"I don't know, I was lots of times very frustrated because I wanted to finish this job and then it is already three hours and please leave this one, go there. It made me angry, frustrated. Then I had a week to and think about it, and taking a break, a break is not for eating. A break is a break because a human being needs a break after two hours of a lot of talking" (Interview, T22, 23/09/17).*

Another teacher, T34, indicated that she was also frustrated many times with the massive amount information. This what she said:

> *"For me it was too much information, and I would be frustrated because I would have to go to class and teach the learners and she is explaining, and I cannot find what she is explaining. I missed some of the things along the way. I was frustrated" (Interview, T34, 23/09/17).*

According to Ertmer (2001), ICT teacher development training should focus on creating learning spaces in which teachers can work at their own pace, and they should not be expected to grasp everything at once, as it seems was experienced by a number of participants in this programme.

Nine of the 17 interviewed teachers reported that they messaged the facilitator when they did not understand or missed information. These teachers reported receiving prompt responses from the facilitator, which enabled them to overcome their confusion and frustration. Another mechanism used by three of the 17 interviewed teachers was to acknowledge that they were all adults and responsible for their own learning. During the interview these three teachers remarked that the facilitator was not there to teach them step by step, but only to guide them. These teachers therefore took it upon themselves to further study and revise on their own, as they would wish their own learners to do. T10 supported his view on this matter by giving the following example. He could not initially find the quizzes he had been required to work through by the next session. Instead of giving up and leaving the work undone, he had explored the resources himself until he made sense of the navigation system so that he could find the quizzes himself without click-by-click instructions *(Interview, T1, T4, T10, T11, T12, T15, T22, T25, T34, T38, T40, T43, T51 & T53, 22/09/17 & 23/09/2017*).

6.6.2 Technical issues

As was explained in detail in Chapter 5, technical issues encountered during the training included poor internet connectivity provided by the campus Wi-Fi and the complexity of the update procedure. The facilitator had tested the software update procedures and online testing system using her home Wi-Fi, and assumed that the university Wi-Fi, which the participants would use, would provide a comparable experience. Additionally, one of the organisers of the programme had also tested the test-writing procedure using the campus internet, with positive results. However, it only became evident during the session with the teachers that the campus internet was erratic and lacked the bandwidth required to accommodate all the teachers at the same time. The Wi-Fi challenges derailed the logins, slowed the sessions, and caused a number of disruptions. There was a lot of content that had to be covered by the facilitator, which caused anxiety. As explained in Chapter 5, internet connectivity was needed to update the software. Because of the Wi-Fi challenges, paired with the observation that many of the participants found the update procedure too complicated. After an initial attempt to let the participants do the updates themselves, the facilitator decided to rather update each participants' files herself while also facilitating the session. This required multitasking and added additional stress to the situation. Wi-Fi challenges also made it impossible to complete the online content tests, which were written at the end of each session. After an initial trial of online testing, paper-based tests were later introduced. The failed initial trial could likely have disillusioned teachers with online testing, affecting their belief systems regarding use of online vs paper-based testing (*Observations, February to September 2017*). The discussion above highlights the disadvantages, including likely disillusionment, resulting from a negative first impression of the use of technology, which was particularly prevalent in the first iteration of the programme.

6.6.3 Participants' expectations of the training

I asked the interviewees whether they had had any expectations about the programme prior to its commencement, and whether these expectations had been met. Most of the interviewees' answers revealed that they had indeed had expectations. The discussion in 6.6.3.1 highlights the interviewees' expectations, and whether these expectations had been met or not. It is therefore important to first understand the participants' prior expectations.

6.6.3.1 Participants' expectation to develop personal skills

From T34's comment, below, it appears that her expectation had been that the programme would develop her basic ICT literacy skills:

> *"I know nothing, and I cannot do anything with a computer…. e.g., I would be setting a question paper and don't even know how to do spacing" (Interview, T34, 23/09/17).*

T34 has noted that even the basic use of Microsoft Word was a problem for her, and that she depended on different people for support to solve what was the challenge at the time. According to T34, she was still struggling with most of the basic computer operations (*Interview, T34, 23/09/17).*

In contrast, T24 started the programme with basic ICT skills, and expected the programme to expose him to more advanced ICT skills, and his expectations were met. This is what he said:

> *"I was exposed to this application, the one we use to ESFile explorer. I never used it before. It was just an accessory for my phone for viewing files. Now I saw that I can store most things online and with that because we have to submit online. My technology skills are now better. If I want to upload something on Drive, I can go there on the ESFile explorer and take it from my phone and put is there, create a link, upload and then (voila!!). Using ESfile explorer more than just a file explorer that is one skill I had gained. Also, the PowerPoint presentations, I used to put in a lot of text. Now it is a different thing. When I see a text, I just find something to replace it with, and I replace it with something visual thing. I think it is powerful for the learners I am teaching" (Interview, T24, 23/09/17).*

Twelve of the seventeen interviewed participants further indicated that they expected the programme to expose them to alternative ways of teaching, in other words favouring ICT instead of the chalk and board. Twelve of the 17 teachers indicated that the programme indeed exposed them to alternative ways of teaching, which was the use of ICT instead of the chalk and board. *(Interview, T1, T4, T10, T12, T15, T23, T24, T40, T43, T45 & T51, T53 22/09/17 & 23/09/2017*).

Four of the 17 participants indicated that at the time of the interviews, they could not tell whether their expectations had been met or not. This is what T4 said:

> *"I had expectations like I said I wanted to close the gap between how I teach and how the learners learn. I had a feeling there was a gap there. I expected that the course will help me to close the gap. I cannot say whether the expectations have been met yet. I think it will be something that will take time to see but on a small scale when I used the tools with the children for instance when we did the interactive simulations for electricity. I could see the impact" (Interview, T4, 23/09/17).*

There have been some notable personal changes, as T4 mentioned, even though some of the teachers were not yet able to comment on whether their expectations had been met or not, citing the need for more time to implement their learning before they would be qualified to make this judgement.

6.6.3.2 Training challenges and mismatch of expectations

The study further revealed that in some cases there was a mismatch of the expectations in terms of the participants (as discussed in 6.6.3.1) and what the programme intended to achieve. In an attempt to discover the reason for this mismatch of expectations, I also interviewed the programme's facilitator. She pointed out that there was a mismatch of expectations between what she had intended to achieve in the programme and what she had come to realise that some participants had actually expected from the programme. The trainer mentioned two issues, namely training challenges and a mismatch between expectations and aspects of the training. These issues are necessary for understanding the change process encountered by the teachers that took part in the training.

a) Training challenges

The trainer (T) firstly noted that some of the participants, like T34, required more support even with simple things:

> *"I have become aware that some people need to be told click by click in every single time. There is no exploration" (Interview, T, 16/09/17).*

Some participants were not able to work independently to explore the activities given and demonstrated to them. The trainer commented on this, saying:

> *"…. person that has that exploratory mind-set or attitude is going to benefit from this course" (Interview, T, 16/09/17).*

The lack of an explorative character was seen by the facilitator as a challenge for some participants. This could have had an impact on the expected change at the end of the programme, which was the improved and effective use of ICT in teaching and learning of Physical Sciences. Furthermore, the facilitator's view was that the participants who lacked an explorative mind-set, required more one-to-one support than had been planned for in the programme. The requirement of one-to-one support had an impact on the progress of all of the participants, as minimal support was given. This increased the likelihood that the participants would go back to their normal use of ICT, which was minimal or non-existence before the training (*Interview, T, 16/09/17*).

b) Mismatch between expectations and aspects of the training

According to the facilitator, a possible cause for the mismatch was that participants wanted a technology-focused course, as seen in the case of T34, while the facilitator focused on pedagogy. Pedagogy should drive technology, and the facilitator never intended that the programme would be focused on fun *(Interview, T, 16/09/17*).

According to the facilitator, some of the participants' expectations was not in line with the purpose of the course, as discussed in detail in paragraph 5.2.2, and this on its own could have affected their attitude towards the training. The result would then be very little difference in the data before and after the training. As the trainer indicated:

> *"If a person is not receiving what they thought they are going to get that can develop negative attitudes and belief system can be harmed and that might be a problem then" (Interview, T, 16/09/19).*

Based on the mismatch of expectations that occurred between some of the participants and what the programme intended to achieve, it is important that teachers' baseline ICT levels are determined before the start of similar professional development opportunities as recommended by Albirini (2006). Another aspect to consider, according to Winslow, Dickerson, Weaver and Josey (2016), is that for a professional development opportunity to be successful, teachers' expectations and needs should be determined. Teachers must participate in the identification of such needs. Lin (2008) asserts that 'one-size-fits-all' training is ineffective, while tailored support-based training on individual needs is more valuable.

Table 6-9: Synopsis of the findings on the interpretation and analysis

Issues	Summary/Sense making	Section
Change of teachers' perceptions regarding the use of ICT	During the professional development opportunity, the teachers' expertise and confidence in using ICT to teach Physical Sciences improved.	6.2.1
	Exposure and support	6.2.1
	Technology knowledge and skills	6.2.1
	ICT can improve the effectiveness and efficiency of the teaching and learning and Physical Sciences	6.2.2
	Positive attitude	6.2.2
	Benefits of ICT	6.2.2
	The use of ICT improved	6.2.3
	The teachers' perception that they can access ICT resources daily to teach Physical Sciences remained low throughout the course of the professional development opportunity	6.2.4
	The teachers' perception that their principals expected and encouraged them to use ICT to teach Physical Sciences remained low throughout the course of the professional development opportunity	6.2.5
Biographical factors and the change in teachers' perceptions regarding the use of ICT	Age, gender, qualifications, school location and school quintile did not influence the change in teachers' perceptions (PU, PEU, PBC, SN and Usage)	6.3.1
	Teachers' teaching experiences may influence their belief that ICT, rather than PEU, PBC, SN, and Usage, may improve the efficacy and efficiency of teaching and learning	6.3.1
The school factors and the teachers' change regarding use of ICT.	Availability and accessibility of ICT resources, policies controlling access to ICT resources, infrastructure, learner enrolment and theft are the school factors that affect teachers' change regarding the use of ICT.	
	Availability of ICT resources	6.3.2.1
	Accessibility of ICT resources	6.3.2.2
	Policies controlling access to ICT resources	6.3.2.3
	Infrastructure and learner enrolment	6.3.2.4
	Theft	6.3.2.5
	Support and maintenance	6.3.2.6
Practices displayed by teachers in their use	Technology is used to enforce teacher-centred practices	6.4.1

of ICT	Technology is used to enhance learner-centred practices	6.4.2
Teachers' perceptions regarding how the use of ICT affects the quality of teaching and learning	The use of ICT improves teaching and learning methods	6.5.1
	The use of ICT improves learner motivation and participation	6.5.2
	The use of ICT influences teacher professional growth	6.5.3
	The use of ICT promotes learner independence and collaboration	6.5.4
	The use of ICT improves learner performance	6.5.5
Issues that arose during the professional development opportunity	Too much information given in a limited time, technical issues such as Wi-Fi and patch challenges, and a mismatch of training expectations were issues that arose during the programme. Teachers responded either positively and negatively towards these issues	6.6
	Technical issues	6.6.2
	Expectations of the training	6.6.3
	Personal skills	6.6.3.1
	Training challenges	6.6.3.2
	One-to-one support	6.6.3.2
	Mismatch of expectations	6.6.3.2
	ICT training vs pedagogical training	6.6.3.2.
	One-size-fits-all training	6.6.3.2
	Training based on teacher needs	6.6.3.2

6.7 CONCLUSION

In this chapter, several assertions have been made in answer to the study's research questions. The study's data have supported these assertions. I recommend that to change teachers' beliefs and practices regarding the use of ICT through subject-specific professional development, the following aspects need to be taken into consideration: how teachers' perceptions change regarding the use of ICT, biographical and school factors that affect changes in the use ICT, how the use of videos, PowerPoint, PhET simulations, Kahoot and quizzes can change teachers' beliefs and practices, how the use of ICT can enhance teacher-centred and learner-centred practices, and how issues such as mismatch of expectations and technical issues such as Wi-Fi and patches that can arise during the training, affect teacher attitude and integration of ICT. In the following chapter, I conclude this thesis by presenting the study's recommendations and conclusion.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This was a case study to determine whether, and how, a group of South African Physical Sciences teachers' beliefs, practices, and teaching quality with regards to the use of ICT in teaching grade 10 Physical Sciences changed, if appropriate, through participating in a subject-specific professional development programme aimed at improving Technological Pedagogical Content Knowledge (TPACK). I will firstly provide an overview of the study to remind the reader of the path I have followed.

7.2 OVERVIEW

The first chapter provided an outline of the study. South African teachers urgently need to increase the rate at which they take up and meaningfully use ICT during teaching There is a need for a face-to-face ICT training for South African teachers (vide 1.2). The integration of TAM and TPB underpins this study (vide 1.5), with pragmatism as the paradigmatic framework (vide 1.6.1). I formulated the main research question (vide 1.3) that informed the aim that guided this study and framed the study through research objectives (vide 1.4). To map a pathway, I provided a synopsis of my research methodology and stated mixed methods as my research approach (vide 1.6.2).

In Chapter 2 I reviewed the literature. I wanted to investigate what research had already been done on the topic, and to place my own research within this body of knowledge. The chapter gave an overview of educational beliefs held by teachers, and such beliefs and their characteristics were described (vide 2.2). The chapter also highlighted the types of ICT beliefs that teachers may hold, and how such beliefs may impact the type of pedagogy that the teacher chooses in the classroom (vide 2.3). The chapter further showed that teaching methods when using technology can be influenced by pedagogical beliefs about technology integration (vide 2.4). This illustrated the link between beliefs and practices (vide 2.5). Research has shown that belief change is a complicated process, so therefore it is interesting to explore how and when belief changes in pre-service and in-service teachers can take place (vide 2.6). To change teachers' beliefs through a programme intended to promote teacher technology usage, a specific sequence of goals should be followed (vide 2.7). Also, there are factors affecting teachers' change in practices and beliefs towards the use of ICT (vide 2.8). There are programmes intended to promote the use of ICT, which were explored in this chapter (vide 2.9). Based on the explored programmes, it was clear that there are a number of aspects to consider when conducting ICT programmes intended to promote the use of ICT by changing teachers' beliefs and practices. The chapter contributed to exposing that teachers' beliefs are central to the decisions they make in the classroom. Therefore, to promote teachers' technology usage through a programme, belief change must be targeted.

Following the literature review, I discussed the theories, model, and framework underpinning this study in Chapter 3. These theories are the Theory of Planned Behaviour and the Technology Acceptance Model. The integration of these two theories contributed indispensable knowledge and insight into understanding processes of predicting human behaviour and technology user acceptance (vide 3.2, 3.3, 3.4, 3.5). An important theme that runs across the two theories is that for a person to accept and use technology, it starts with the intention to accept and use it, and that is why both of them are called intention models. The integrated model of the two theories predicts that the intention to use and accept technology (vide 3.7.3) is directly influenced by the attitude towards technology use (vide 3.3.2), which is in turn influenced by perceived usefulness (vide 3.6.1) and perceived ease of use (vide 3.6.2), subjective norms (vide 3.3.3), perceived behavioural control (vide. 3.3.4), and perceived usefulness (vide 3.6.1). The integrated model further indicates that ICT usage (vide 3.7.2) is one of the measures of acceptance of technology. The use of technology can be self-reported or observed (vide 3.7.2). Both theories predict that there are external variables that influence beliefs (vide 3.5, 3.3.5). The chapter further discussed the Substitution, Augmentation, Modification, and Redefinition model (vide 3.9.). This model assisted me to determine and understand the level at which technology was used in this study. Lastly, the chapter discussed the TPACK framework, which informed the SLP used in the case study. This chapter assisted me to understand how technology acceptance and use occurs, and how teachers can use technology at different levels.

The next chapter unpacked the research methodology and tools used to investigate how South African teachers' beliefs, practices, and quality of learning regarding the use of technology in teaching changed when they experienced subject-specific professional development opportunities based on TPACK principles. A sequential exploratory and explanatory mixed methods research design was used to answer the research questions. (vide 4.4). Data collection was pragmatically done in seven stages, and various methods were used (vide 4.2). The chapter discussed how the data tools were designed (vide. 4.5.1.2, 4.5.2.4, and 4.5.3.1), how collected data were analysed (vide 4.8), how the quality of data was ensured (vide 4.9), and information was provided on the study's sample (vide 4.6). The chapter concluded by presenting the research ethics observed throughout this study (vide 4.10).

In Chapter 5 I provided details on the short learning programme to paint a picture in the readers' mind about this South African-based programme (vide 5.2.1). Information was provided on the following: the general context of the programme in terms of background (vide 5.2.1), the structure of the programme (vide 5.2.3), duration of the programme (cf. 5.2.3), the biographical context of participants (vide 5.3.1), and the context and philosophy of the programme (vide 5.2.4). The programme is grounded in promoting TPACK (vide 5.2.2). The chapter further discussed communication tools in the programme (vide 5.2.5). The success of the integration of ICT depends on school contexts, so I discussed them to paint a picture in the readers' mind of the day-to-day challenges facing our teachers (vide 5.3.1). The final assessment tasks of three selected teachers, from three different levels of technological competence (vide 5.3.3), were discussed in detail. Lessons learned from these identified teachers' assessment tasks were described in detail (vide 5.3.3. - 5.3.5).

Chapter 6 sought to reveal insights that could be gained from a South African professional development opportunity aimed at changing teachers' beliefs, practices, and teaching quality related to the use of ICT. I did this by exploring the experiences of Grade 10 Physical Sciences teachers through the course of a professional development programme, by observing their interactions, participation, etc. during sessions, analysing their responses through pre- and post-questionnaires, interviewing selected teachers in focus groups, and the moderation of their final assessment task. I found that through the course of the professional development opportunity, aimed at promoting

TPACK, the following occurred: the teachers’ knowledge and confidence to use ICT improved (vide 6.2.1), ICT can improve the effectiveness and efficiency of the teaching and learning of Physical Sciences (vide 6.2.2), and the use of technology to teach Physical Sciences improved through the course of the professional development opportunity (vide 6.2.3). On the other hand, the teachers’ perceptions that they could access ICT resources daily, and that their principals expected and encouraged them to use ICT to teach Physical Sciences, remained low through the course of the professional development opportunity (vide 6.2.4 & 6.2.5). The discovery was also made that age, gender, qualifications, school location and school quintile did not influence the change in teachers’ perceptions regarding the use of ICT through the course of the professional development opportunity. However, the teachers’ teaching experience could influence their perception that ICT can improve the effectiveness and efficiency of teaching and learning, and not PEU, PBC, SN and Usage (vide 6.3). The analysis further revealed that availability and accessibility of ICT resources, policies controlling access to other ICT resources, infrastructure, learner enrolment and theft are the school factors that affect teachers’ change regarding the use of ICT (vide 6.3). The results further showed that most teachers used technology to enhance teacher-centred practices at the substitution and augmentation levels, while few teachers used technology to enhance learner-centred practices at the modification and redefinition levels (vide 6.4). Despite how ICT was used, teachers in this study perceived the use of ICT to improve the quality of teaching and learning. Hence, several benefits of using ICT were noted in this study (vide 6.4). Lastly, despite the intentions of any professional development, there will be issues that arise, as was the case in this study. These issues included too much information imparted in a limited time, technical issues such as Wi-Fi and patch challenges, and a mismatch of training expectations (vide 6.6). This chapter made a meaningful contribution towards exposing and helping me to determine insights that can be gained from a South African professional development opportunity aimed at changing teachers’ beliefs, practices, and teaching quality related to the use of ICT.

In this chapter I attempt to make sense of how South African teachers' beliefs, practices, and teaching quality with regarding the use of technology in teaching changed when they experienced subject specific professional development opportunities based on TPACK principles. I will firstly provide a synopsis of how such a change can occur (as discussed in section 7.3), then make certain recommendations (as discussed in section 7.4), and finally, by reflecting on the study as a whole (as discussed in section 7.5), its contribution (as discussed in section 7.5.1), suggestions for further studies (as discussed in section 7.6), and limitations (as discussed in section 7.7).

7.3 SUMMARY OF KNOWLEDGE CLAIMS

Having completed this study I am convinced that it is possible for teachers' perceptions regarding the use of ICT to improve when teachers participate in subject-specific professional development programmes. Such a shift in perceptions takes time and effort, and is likely to be accompanied by considerable challenges. This view arises from the findings of this study, summarised in the following assertions, which answer the research questions.

Assertion 1: Through the course of the professional development opportunity aimed at promoting TPACK, the teachers' knowledge and confidence to use ICT improved. Both before and after the programme teachers were very optimistic about the potential of ICT to improve the effectiveness and efficiency of the teaching and learning of Physical Sciences. This optimism was slightly tempered across the course of the programme. The teachers perceived that their integration of ICT usage into their Physical Sciences teaching improved across the course of the programme. However, the teachers' perceptions regarding the extent to which they could access ICT resources daily, and to which their principals expected and encouraged them to use ICT to teach Physical Sciences, remained low throughout the course of the professional development.

Assertion 2.1: Age, gender, qualifications, school location and school quintile did not influence the teachers' perceptions regarding the use of ICT changed through the course of the professional development opportunity. The teachers in the most experienced category experienced the greatest decline in their perception of the usefulness of ICT in teaching, across the programme.

Assertion 2.2: The availability and accessibility of ICT resources and infrastructure appropriate to figures of learner enrolment, served as barriers to the participants' use of ICT in their respective schools. Where the schools had no ICT policies, there was inequitable access to ICT resources.

Assertion 3: Most teachers used technology to enhance teacher-centred practices at substitution and augmentation levels. A few teachers used technology to enhance learner-centred practices at modification and redefinition levels.

Assertion 4: Most teachers perceived that integration of ICT in the teaching of Physical Sciences is likely to result in improved: (a) ways of teaching and learning, (b) learner motivation and participation, (c) teacher professional growth, (d) learner independence and collaboration, and (e) improved learner performance.

Assertion 5: Issues which arose during the programme included difficulties with (a) being presented with a large amount of new information within a limited time, (b) technical difficulties such as poor connectivity and the complexity of the update procedure, (c) the expectation, held by some participants with very low technological skills, that the programme would focus on the development of these skills, rather than on technological knowledge and PCK. Some teachers responded to these difficulties by becoming frustrated, while others become more self-directed in their learning. The first iteration of this programme, reported on here, exposed unanticipated challenges which later iterations would benefit from in hindsight. It also exposed the need for providing different programmes for teachers of different baseline levels of ICT skill.

In addition to these assertions, I further present a framework in Figure 7.1 and a model in Figure 7.2 on how to promote ICT usage and acceptance in South African schools.

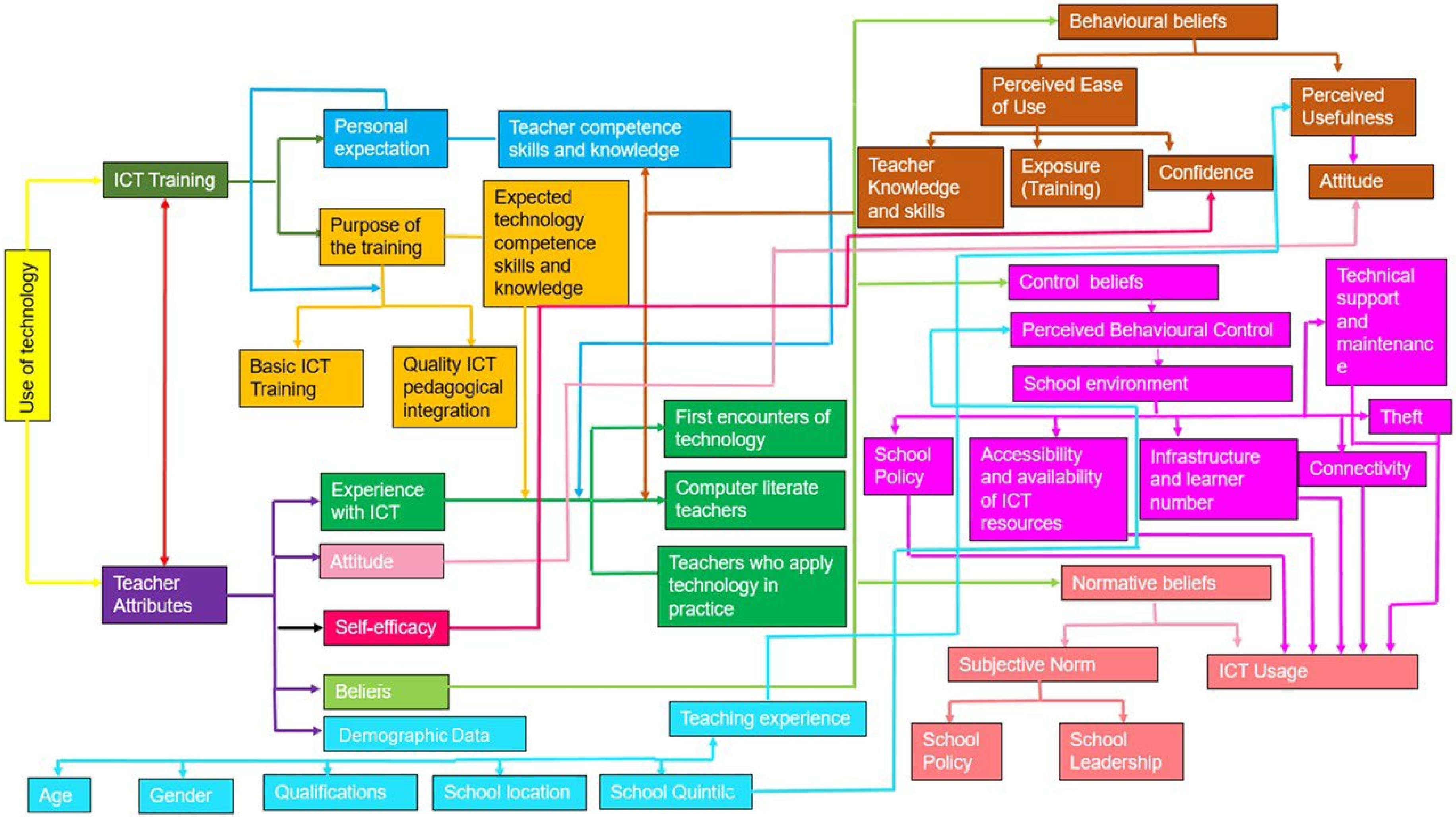


Figure 7-1: Framework to promote use and acceptance of ICT

The purpose of the framework is to propose to all stakeholders, including governmental and non-governmental organisations, how ICT usage can be promoted. Through the framework I suggest that the training of teachers on how to use ICT is one of the ways in which the use of ICT can be promoted. The diagram illustrates aspects to be addressed in an ICT training course for ICT usage to be promoted. Through the framework I suggest that the ICT training must have a clear purpose from the beginning or before the training starts. For example, will the ICT training cover only basic ICT skills, or quality ICT pedagogical integration training, or promote principles of the TPACK framework? The clear purpose of the ICT training will then guide which technological skills participants should have before participating in training of this nature. It is important to consider the participants' varying technological skills, since there will be people encountering technology for the first time, together with computer literate participants and participants who can apply technology in practice. Therefore, by differentiating the participants' technological competence skills, the less likely a contradiction between participants' expectations and the intended programme outcomes will be. In simple terms, the diagram suggests that if ICT training is to promote the use of ICT, such training should be tailor-made to meet the individual participants' needs. The failure of the Khanya Project (vide 2.9.2), Intel® Teach to the Future (vide 2.9.3) and New Opportunities Fund ICT training (vide 2.9.4) to promote the use of ICT, was due to the fact that neither of the approaches used in these projects could recognise teachers' different ICT competencies, and the non-specification of the type of training that the teachers were to receive. Hence, I propose the above ICT training framework.

As shown in the framework there are teacher attributes such as experiences with ICT by teachers (vide 2.10.1), teacher attitude (vide 6.2.2), teacher self-efficacy (vide 2.8.4.1), biographical data (vide 6.3.1), and beliefs (vide 3.2 & 3.5) that teachers hold that contribute to technology usage and acceptance. The beliefs are classified into behavioural beliefs, control beliefs and normative beliefs. Additionally, there are external factors that directly influence the beliefs that teachers hold, which in turn indirectly influence the behavioural intention to use and accept ICT. The impact of the external factors on the acceptance and usage of ICT is summarised in the model presented in Figure 7.2 below. The purpose of the model is to highlight these external factors to all stakeholders, including governmental and non-governmental organisations.

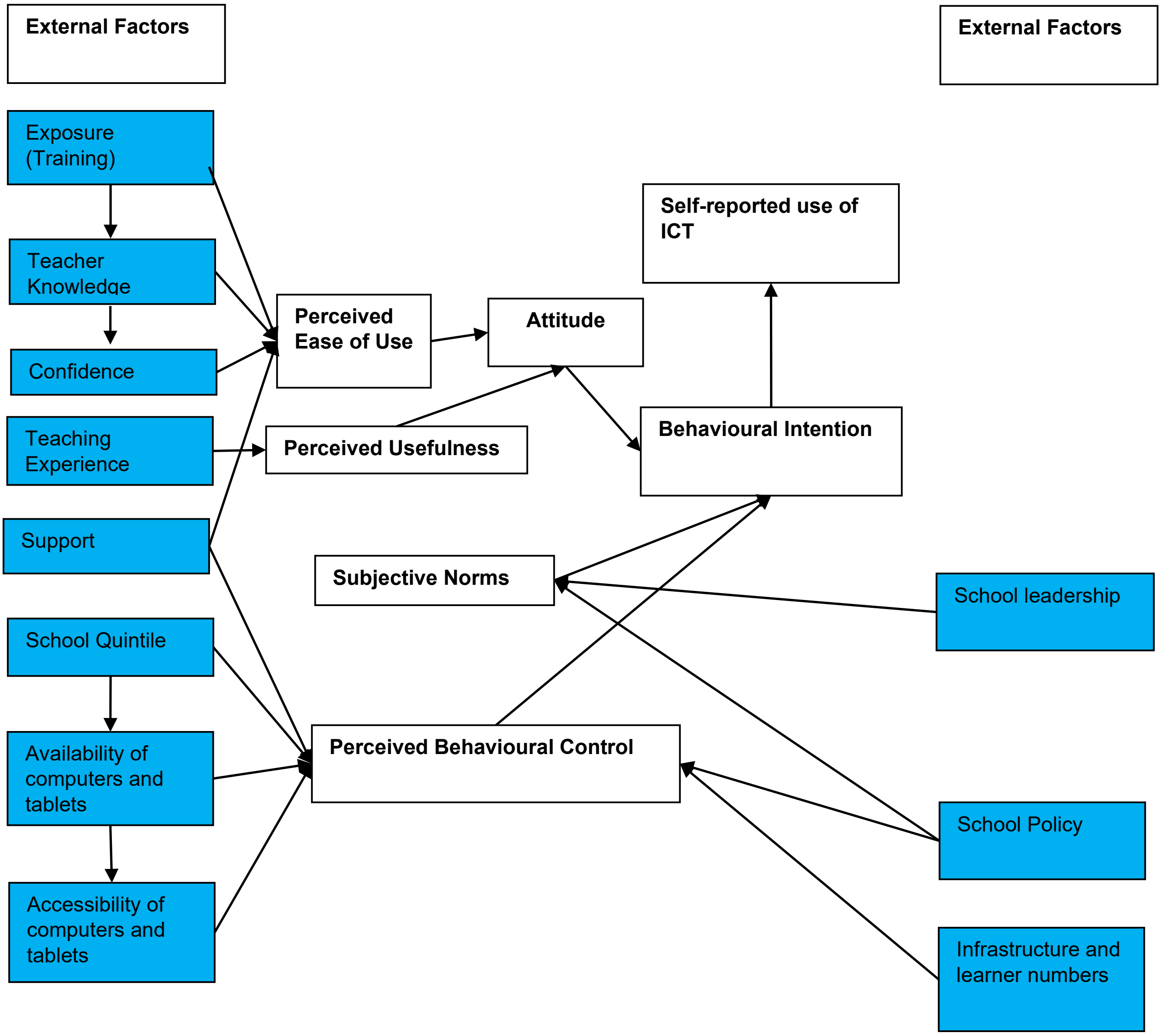


Figure 7-2: Model to promote ICT use in teaching and learning

The model retains the basic structure of Pynoo and Van Braak's (2014) technology acceptance and the theory of planned behaviour, although perceived usefulness is given as a predictor of attitude and not influencing perceived ease of use, as in these models. This alteration is consistent with the findings, given in paragraph 6.2, that the teachers in this sample generally expected the outcome of ICT usage to positively influence their teaching. They also believed that technology could help them to achieve professional or personal tasks more efficiently (vide 6.5.3).

The external factors in this model emerged from this study when data were quantitatively and qualitatively analysed and interpreted. The model suggests the following:

a) Teachers' confidence to use and accept technology can be influenced by their exposure to ICT training. This confidence emanates from the skills and knowledge they would have gained during ICT training. Therefore, ICT training plays an important role in ensuring that teachers can gain the skills, knowledge, and confidence to use and accept technology during teaching.

b) It is important that there is proper infrastructure in South African schools so that computers are available and accessible by both teachers and learners, even in schools with a high learner enrolment figure. Along with accessibility and availability, there should be a school ICT policy to ensure the fair and equitable distribution of ICT resources in schools. The availability of a school ICT policy will among other things address issues of the accessibility and availability of computers during teaching and learning, and how ICT resources can be managed optimally in schools.

c) The use and acceptance of technology requires that the school leadership, especially the principal and the school management team, assume a transformational role. The principal and the SMT must ensure that the school ICT policy covers all subjects.

d) When teachers believe that the use of ICT will impact positively towards teaching and learning, then usage and acceptance is likely to occur.

To achieve one of the educational goals, which is ICT acceptance and usage during teaching and learning, the external factors as discussed should be addressed in South African schools.

7.4 RECOMMENDATIONS OF THE STUDY

To change teachers' beliefs and practices regarding the use of ICT, the following recommendations are made:

7.4.1 Recommendation to conduct teacher professional training

The study revealed that for most of the teachers involved in the programme, their knowledge and confidence to use ICT to teach Physical Sciences improved through the course of the subject-specific professional development opportunity (vide 6.2.1), grounded to promote the TPACK framework (vide 5.2.2). Therefore, the study recommends that teachers be exposed to subject-specific professional development opportunities grounded to promote TPACK principles (vide 3.11). The purpose of the subject-specific professional development opportunity, based on TPACK principles, is to promote teachers' reflection on their content knowledge and pedagogical knowledge, and for them to relate this to their technological knowledge to yield technological pedagogical knowledge. Additionally, the study further recommends that professional development opportunities are tailor-made according to baseline ICT competence at the start of the programme. This means that there should be different programmes for people who start with little to no ICT competence and for those who start with average to good ICT competence.

7.4.2 Recommendation for school leadership

The study revealed that there is minimal or no involvement of the principal, the school management team (vide 6.2.5), and the school governing body in schools where teachers came from. The non-involvement of school leadership harms the adoption and implementation of ICT at a school. It is a fact that you cannot lead and manage what you do not know. Chances are that if you are a school leader, leading a teacher who knows how to use ICT better than you, you will have no interest in the matter and offer little or no support to the teacher that knows how to use ICT. The study revealed that some principals felt that the teachers who wanted to make changes by implementing ICT, wanted to tell them how to lead and run their schools. Therefore, the study recommends that the principal, the school management team, and the school governing body be exposed to technology teacher training in order for them to be able to know how to lead and manage from the front in the implementation of ICT in South African schools.

The study further revealed that the non-availability of ICT infrastructure in schools where the teachers came from, impact negatively on the implementation of ICT (vide. 6.3.2.1). In some schools, the ICT infrastructure is there, but it appeared subjects like Mathematics and computer applications technology are more favoured than others like Physical Sciences, and these cause conflict and tension amongst teachers in the same school (vide 6.3.2.3). Therefore, the study recommends that principals as ICT leaders at the school level must lead the process of drawing up an infrastructure policy. The infrastructure policy will prevent the favouring of certain subjects favoured more than others, minimise tensions in schools, and advance a sense of shared ownership of resources for teachers and learners of other subjects.

7.4.3 Recommendation for the Department of Education

The study also revealed that there was no guiding ICT policy for South African schools on how ICT should be implemented in many of the schools where teachers in this sample came from (vide 6.2.2.3). This absence of school-based ICT policies and plans have resulted in the non-use of available ICT resources, as discussed in detail in 6.3.2.3. There is an urgent need to guide schools to develop sensible and well-defined ICT policies and realistic and executable implementation plan. The following could be included in the guidelines for school policies:

- Policies should provide clarity on what the particular school aims to achieve with ICT integration and justify these.

- Such a policy should not be imposed, but collaboratively developed by all stakeholders including the school management team, the school governing body, teachers and where possible even learners.

- Schools should establish ICT committees and designate a competent and enthusiastic staff member who will oversee all matters about ICT usage at the school, and act as leader and champion to motivate and assist teachers to use ICT.

- Collaboration between ICT leaders and champions from neighbouring schools provide a space for deliberations, capacity building and support.

7.5 REFLECTIONS ON THE STUDY

The study has accomplished its main research aim, which was to determine how a group of South African Physical Sciences teachers' beliefs and practices with regards to the use of ICT in teaching changed (or not) through experiencing a subject-specific professional development programme aimed at improving TPACK (cf. 1.4).

The study has illuminated that the beliefs that teachers hold drive many of the choices they make in the classroom. The study succeeded in mapping the complicated nature of such beliefs, and how beliefs inform the pedagogical choices teachers make in the classroom, as reflected in Chapter 2. This was a critical step in the study, because the programme at hand intended to promote technology usage by changing teachers' beliefs and practices. The two theories used in this study provided the lens to explain why a person decides to display specific behaviour, as reflected in Chapter 3. They both predict that behaviour is stimulated by intention, which in turn is influenced by underlying beliefs. They further indicate the presence of external variables, which indirectly influence technology acceptance and use. This was helpful to me to understand the complexity of the belief change process, which lies at the centre of behaviour.

The many sources of data collection, including pre- and post-questionnaires, group interviews and the assessment task used in this study, exposed me to massive amount of information. I used this to determine how South African teachers' beliefs and practices change with regards to the use of ICT in teaching, when they experience subject-specific professional development opportunities based on TPACK principles.

The interviews I conducted exposed me to the daily problems that teachers encounter regarding the availability and accessibility of ICT resources. What came as a shock to me was the allocation of ICT resources, in particular tablets, laptops, and computers, to subjects like CAT and Mathematics. This allocation denied the teachers and learners of Physical Sciences (and other subjects) access to the available ICT resources at schools. It was alarming to know that the majority of principals are not involved in the process of ICT integration. These day-to-day challenges experienced by teachers are defeating the Departmental goal that ICT is to be integrated in South African schools.

Personally, I also learnt a great deal from this study. Like most people, I thought that ICT integration was about being able to do a PowerPoint presentation, type a question paper and lesson plans, and capture learners' marks on a spreadsheet. My involvement in this project corrected this perception, but unfortunately most people and our partners in education still hold this perception. ICT integration is so much more than what I thought it was.

7.5.1 Value of the research

It is my strong belief that this study, through its findings, will contribute towards expanding the knowledge and understanding of how to promote teacher usage of technology through South African-based teacher training programmes. There is a great need for a South African-based contextualised ICT programme.

With all the practical recommendations I put forward, I hope this study will benefit educational practitioners, school leadership, and partners in education on how to promote ICT integration in South African schools. There is an urgent need for a guiding policy to schools on how to integrate ICT, and school policies on how to integrate technology. When these policies are available in those schools that do not have, guidance will be given to the partners in education to align their projects towards achieving the goals stated in the departmental and school policy regarding ICT integration. One of the conditions from the Department of Education in granting permission to undertake the study was that I needed to submit both a hard copy and an electronic version of this thesis to them. It is my sincere hope that the relevant managers from the Department will read the recommendations of the study and implement them, specifically with regards to the non-availability of proper infrastructure that enables ICT integration in most South African schools, especially schools located in rural areas.

7.6 SUGGESTIONS FOR FURTHER RESEARCH

This study focused on how grade 10 Physical Sciences' teachers' beliefs and practices with regards to the use of ICT in teaching can change when they experience subject-specific professional development opportunities based on TPACK principles through a top-down ICT teacher training approach. Further research on the impact of the bottom-up ICT teacher training approach should be investigated. Focus should be placed on the role played by South African principals' ICT leadership knowledge and skills, since this study suggests that principals predominantly are not dedicated to their role as ICT leaders at their schools.

7.7 LIMITATIONS

The following limitations are evident in this study:

7.7.1 Layers of subjectivities

In this study, there are various subjectivities that I want to acknowledge.

7.7.1.1 Insider bias

The first limitation is that my promotor is the person who presented the short learning programme. This could have led to unacceptable levels of subjectivity and bias. To counteract this subjectivity, a co-promotor was appointed who was not in any way involved in the short learning programme. Furthermore, my promotor made it clear from the start that any weaknesses identified in the study would lead to the improvement of the short learning programme, and that she was therefore keen on any feedback.

7.7.1.2 Researchers' subjectivity

The second limitation of this study is the way in which teachers were selected to participate in the semi-structured interviews, which may have biased certain views and excluded others. I conveniently selected teachers who I interviewed because I believed that they would provide me with the answers I need to answer the research questions. I selected 17 teachers who I understood to have demonstrated the following changes in their beliefs and practices regarding the use of ICT to teach Physical Sciences: a significant shift (n=6), modest change (n=7); no change (n=4). I used other forms of data, i.e. the questionnaires and my observation notes. to guide my selection process to increase the validity of my judgements.

7.7.1.3 Professional bias

The third limitation is that of professional bias. All the teachers who participated in the short learning programme know my involvement in Physical Sciences as their subject advisor. This might have influenced how they responded to the questions, and they might not have been truly honest with how they felt. To reduce this bias, I set the tone and the interview atmosphere to be that of a relaxed and comfortable mode for them to answer questions with honesty. I further explained to the interviewees the purpose of the interview which was get their honest answers to enable me to answer the research questions.

7.7.2 Generalisability

Lastly, as with any small-scale research study, the major limitation is that of generalisability. However, it is possible to claim 'face-generalisability' (Maxwell 1996; Schofield 1993) based on the typicality of the schools and their contexts. Furthermore, the descriptive teacher contexts provided in Chapter 5 provide researchers and teachers with some basis for comparison with their contexts, towards the ideal of transferability.

7.8 CONCLUSION

In the Fourth Industrial Revolution, all stakeholders need to work together. Teachers need skills to implement, manage, and work with new technology. In view of the subject-specific professional development programme, teachers were provided with pedagogically sound tools that created new and innovative models of teaching that maximised the learning opportunities and skills they needed to implement and work with technology. As a result, their beliefs and practices regarding the use of ICT changed (vide 6.2 and 6.5).

I have embarked on this Ph.D. journey with enthusiasm and optimism to learn about how a South African sample of Free State grade 10 teachers' beliefs, practices, and teaching quality can change, where necessary, with regard to the use of ICT in teaching when they experience subject-specific professional development opportunities based on TPACK principles. I did not do this study for myself, but for other stakeholders and partners. My plans, therefore, include transforming the findings of this study into support programmes in the Free State Department of Education where I am currently employed.

REFERENCES

Abidoye, J.A. (2015). The effect of blended learning instructional approach on secondary school student's academic achievement in geography in Akure, Ondo State, Nigeria. *Research Journal of Educational Studies and Review*, 1(5), pp. 106-110. Available at http://www.pearlresearchjournals.org/journals/rjesr/archive/2015/Sep/Abstract/Abidoye.html (Accessed 12 April 2017).

Adams, D.A., Nelson, R.R., & Todd, P.A. (1992). Perceived usefulness, ease of use, and usage of information technology: a replication. *MIS quarterly*, June, pp. 227-247. Available at https://www.jstor.org/stable/pdf/249577.pdf (Accessed 26 April 2018).

Afshari, M., Abu Bakar, K., Su Luan, W., Abu Samah, B., & Say Fooi, F. (2009). Factors Affecting Teachers' Use of Information and communication technology. *International Journal of Instruction,* 2(1), pp. 78–104. Available at https://www.e-iji.net/dosyalar/iji_2009_1_5.pdf (Accessed 29 June 2017).

Aguti, J.N. (2016). ICT Integration and Digital Competencies – a must for 21st century teachers. [Online]. Available at: http://hdl.handle.net/11599/1766 (Accessed 26 June 2020).

Ahmed, K.A. (2013). Teacher-Centred Versus Learner -Centred Teaching Style. *The Journal of Global Business Management*, Volume 9(1). Available at: http://www.jgbm.org/page/3%20Ahmed%20Khaled%20Ahmed.pdf (Accessed 24 October 2017).

Airasian, P.W. (1987). State mandated testing and educational reform: context and consequences. *American Journal of Education*, 95(3), pp. 393-412. https://doi.org/10.1086/444312

Ajzen, I. (1985). From intentions to action: A theory of planned behaviour. In J. Kuhl & J. Beckman (Eds.), *Action-control: From cognition to behaviour*, (pp. 11-39).

Heidelberg: Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), pp. 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2006). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*, 32(4), pp. 665-683. https://doi.org/10.1111/j.1559-1816.2002.tb00236.x

Ajzen, I. (2011). The theory of planned behavior: Reactions and reflections. *Psychology & Health*, 26(9), pp. 1113-1127. https://doi.org/10.1080/08870446.2011.613995

Ajzen, I., & Manstead, A.S. (2007). Changing health-related behaviours: An approach based on the theory of planned behaviour. In M. Hewstone, H.A.W. Schut, J.B.F. De Wit, K. Van Den Bos, & M.S. Stroebe (Eds.), *The scope of social psychology: Theory and applications* (pp. 43–63). New York: Psychology Press.

Akbulut, Y., Kesim, M., & Odabasi, H.F. (2007). Construct validation of ICT indicators measurement scale (ICTIMS). *The International Journal of Education and Development using Information and Communication Technology* (IJEDICT), 3(3), pp. 60-77. Available at http://ijedict.dec.uwi.edu/include/getdoc.php?id=2394&article=359&mode=pdf (Accessed 23 November 2017).

Al Haderi, S.M., & Aziz, B.N. (2015). The Effect of Social Characteristic in the Acceptance and Continue Usage for Information Technology in the Public Sector. *International Journal of Business and Social Science* 6(7), pp. 186–192. Available at http://ijbssnet.com/journals/Vol_6_No_7_July_2015/19.pdf (Accessed 17 February 2018).

Albion, P. (2003). Graduating teachers' dispositions for integrating information and communications technologies into their teaching. Society for Information. Available at https://www.learntechlib.org/primary/p/18232/ (Accessed 15 December 2017).

Albion, P., & Ertmer, P. (2002). Beyond the foundations: The role of vision and belief in teachers' preparation for integration of technology. *TechTrends*, 46(5), pp. 34-38. https://doi.org/10.1007/BF02818306

Albirini, A. (2006). Teachers' Attitudes toward information and communication technologies: The case of Syrian EFL teachers. *Computers and Education*, 47(4), pp. 373-398. https://doi.org/10.1016/j.compedu.2004.10.013

Alharbi, S., & Drew, S. (2014). Using the Technology Acceptance Model in Understanding Academics' Behavioural Intention to Use Learning Management Systems. *International Journal of Advanced Computer Science and Applications,* 5(1), pp. 143–155. https://dx.doi.org/10.14569/IJACSA.2014.050120

Almerich, G., Orellana, N., Suárez-Rodríguez, J., & García, I. (2016). Teachers' information and communication technology competences: A structural approach. *Computers & Education*, 100, pp. 110–125. https://doi.org/10.1016/j.compedu.2016.05.002

Altawallbeh, M., Soon, F., Thiam, W., & Alshourah, S. (2019). Mediating Role of Attitude, Subjective Norm and Perceived Behavioural Control in The Relationships Between Their Respective Salient Beliefs And Behavioural Intention To Adopt E-Learning Among Instructors In Jordanian Universities. *Journal of Education and Practice*, 6(11), pp. 152-159. Available at https://www.iiste.org/Journals/index.php/JEP/article/view/21872 (Accessed 24 April 2018).

Alzheimer Europe. (2013). The four main approaches. Available at http://www.alzheimer-europe.org/Research/Understanding-dementia-research/Types-of-research/The-four-main-approaches (Accessed 12 August

2017).

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1), pp. 71–88. Available at https://citejournal.org/wp-content/uploads/2016/04/v9i1general2.pdf (Accessed 20 June 2018).

Arntzen, J., & Krug, D. (2011). ICT ecologies of learning: Active socially engaged learning, resiliency and leadership. In S. D'Agustino (Ed.), *Adaptation, resistance and access to instructional technologies: assessing future trends in education* (pp. 332–354). Hershey, PA: Information Science Reference.

Aslan, A., & Zhu, C. (2016). Influencing factors and integration of ICT into teaching practices of pre-service and starting teachers. *International Journal of Research in Education and Science*, 2(2), pp. 359-370. Available at https://files.eric.ed.gov/fulltext/EJ1105123.pdf (Accessed 21 August 2018).

Atkins, N.E., & Vasu, E.S. (2000). Measuring knowledge of technology usage and stages of concern about computing: A study of middle school teachers. *Journal of Technology and Teacher Education*, 8(4), pp. 279-302. Available at https://www.learntechlib.org/primary/p/8038/ (Accessed 24 October 2018).

Aversano, N. (2005). Technology rejection of Mobile Telephones Unpublished Doctor of Management Program, Case Western Reserve University United States.

Bakir, N. (2016). Technology and teacher education: A brief glimpse of the research and practice that have shaped the field. *TechTrends*, 60(1), pp. 21–29.

Banerjee, A.S., Cole, S., Duflo, E., & Linden, L. (2007). Remedying education: Evidence from two randomized experiments in India. *Quarterly Journal of Economics*, 122(3), pp. 1235-1264. http://dx.doi.org/10.1162/qjec.122.3.1235

Barlow, A., & Cates, J. (2006). The impact of problem posing on elementary teachers' beliefs about mathematics and mathematics teaching. *School Science and Mathematics*, 106, pp. 64–73. https://doi.org/10.1111/j.1949-

8594.2006.tb18136.x

Barnard-Bark, L., Burley, H., & Crooks, S.M. (2010). Explaining youth mentoring behaviour using theory of planned behaviour perspective. *International Journal of Adolescence and Youth*, 15(4), pp. 365–379. https://doi.org/10.1080/02673843.2010.9748040

Barrett, C. (2000). Keynote Address presented at the National Educational Computing Conference (NECC), 27th June 2000. Atlanta, Georgia. Available at: http://www.intel.com/pressroom/archive/speeches/cb062700.htm (Accessed 21 October 2017).

Bauer, J., & Kenton, J. (2005). Technology integration in the schools: Why it isn't happening. *Journal of Technology & Teacher Education*, 13(4), pp. 519-526. https://www.learntechlib.org/primary/p/4728/

Becker, H.J. (2000) Findings from the teaching, learning, and computing survey: is Larry Cuban, right? *Educational Policy Analysis Archives,* 8, 51. https://doi.org/10.14507/epaa.v8n51.2000

Bennet, N. (2008). Distributed Leadership and IT. In J. Voogt & G. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education,* 2 *(*pp. 597-613). New York: Springer.

Berrett, B., Murphy, J., & Sullivan, J. (2012). Administrator insights and reflections: Technology integration in schools. *The Qualitative Report*, 17(1), pp. 200–221. https://doi.org/10.46743/2160-3715/2012.1815

Beswick, K. (2007–2008). Influencing teachers' beliefs about teaching mathematics for numeracy to students with mathematics learning difficulties. *Mathematics Teacher Education and Development*, 9, pp. 3–20. Available at https://files.eric.ed.gov/fulltext/EJ822098.pdf (Accessed 2 December 2018).

Bhandari, P. (2021). Ethical considerations in Research. Available at: https://www.scribbr.com/methodology/research-ethics (Accessed 18 February

2022).

Bielaczyc, K., & Collins, A. (1999). Learning Communities in Classrooms: A Reconceptualization of Educational Practice. In C. Reigeluth (Ed.), *Instructional-design theories and models. A new paradigm of instructional theory,* 2 (pp. 269–292). Mahwah, NJ: Lawrence Erlbaum Associates.

Bingimlas, K.A. 2009. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science & Technology Education*, 5(3), pp. 235–245. https://doi.org/10.12973/ejmste/75275

Bladergroen, M., Chigona, W., Bytheway, A., Cox, S., Dumas, C. & Van Zyl, I. (2012). Educator discourses on ICT in education: A critical analysis. International *Journal of Education and Development using ICT*, 8(2), pp. 107-119. Available at http://ijedict.dec.uwi.edu/viewarticle.php?id=1430 (Accessed 31 January 2019).

Bleakley, A., & Hennessy, M. (2012). The quantitative analysis of reasoned action theory. *Annals of the American Academy of Political and Social Science,* 640, pp. 28–41. Available at https://www.jstor.org/stable/23218421 (Accessed 24 February 2019).

Blignaut, S., Els, C., & Howie, S. (2010). Contextualizing South Africa's participation in the SITES 2006 module. *South African Journal of Education*, 30(4), pp. 555-570. Available at https://www.ajol.info/index.php/saje/article/view/61784 (Accessed 14 April 2019).

Bolster, A.S. (1983). Toward a more effective model of research on teaching. *Harvard Educational Review*, 53(3), pp. 294-308. https://doi.org/10.17763/haer.53.3.0105420v41776340

Bonk, C.J., & Graham, C.R. (2005). *Handbook of blended learning*: *Global Perspectives, local designs*. San Francisco, CA.: Pfeiffer Publishing.

Borko, H., & Putnam, R.T. (1995). Expanding a teacher's knowledge base: A cognitive psychological perspective on professional development. In T.R. Guskey & M. Huberman (Eds.), *Professional development in education: New paradigms & practices* (pp. 35–66). New York: Teachers College Press.

Bosnjak, M., Tuten, T.L., & Wittmann, W.W. (2005). Unit (non)response in web-based access panel surveys: An extended planned-behaviour approach. *Psychology & Marketing*, 22(6), pp. 489-505. https://doi.org/10.1002/mar.20070

Bourgonjon, J., De Grove, F., De Smet, C., Van Looy, J., Soetaert, R., & Valcke, M. (2013). Acceptance of game-based learning by secondary school teachers. *Computers & Education*, 67, pp. 21–35. https://doi.org/10.1016/j.compedu.2013.02.010

Bowling, A. (2005). Mode of questionnaire administration can have serious effects on data quality. *Journal of Public Health*, 27(3), pp.281–291. https://doi.org/10.1093/pubmed/fdi03

Bradshaw, L.K. (2002). Technology for teaching and learning: strategies for staff development and follow-up support. *Journal of technology and teacher education*, 10(1), pp. 131-150. Available at https://www.learntechlib.org/primary/p/9307/ (Accessed 17 July 2019).

Bredeson, P.V., Fruth, M.J. & Kasten, K.L. (1983). Organizational incentives and secondary school teaching. *Journal or Research and Development in Education*, 16(4), pp. 52-58.

British Educational Research Association [BERA] (2018) Ethical Guidelines for Educational Research, fourth edition, London. Available at: https://www.bera.ac.uk/researchers-resources/publications/ethicalguidelines-for-educational-research-2018 (Accessed 18 February 2022).

Brown, J.K. (2008). Student-centred instruction: involving students in their own education. *Music Educators Journal*, 94(5), pp. 30-35. https://doi.org/10.1177/002743210809400508

Brown, P. (2015). A guide for bringing the SAMR model to iPads. Available at: https://www.edsurge.com/news/2015-02-06-a-guide-for-bringing-the-samr-model-to-ipads (Accessed 24 May 2018).

Brown, S.A., Massey, A.P., Montoya-Weiss, M.M., & Burkman, J.R. (2002). Do I really have to? User acceptance of mandated technology. *European Journal of Information Systems*, Volume 11(4), pp. 283–295. https://doi.org/10.1057/palgrave.ejis.3000438

Brown, T.H. (2006). Beyond constructivism: Navigationism in the knowledge era. *On the Horizon*, 14(3), pp. 108-120. https://doi.org/10.1108/10748120610690681

Brownlee, J. (2003). Changes in primary school teachers beliefs about knowing: A longitudinal study. *Asia-Pacific Journal of Teacher Education,* Volume 31(1), pp. 87–98. https://doi.org/10.1080/13598660301621

Brownlee, J., & Chak, A. (2007). Hong Kong student teachers' beliefs about children's learning: Influences of a cross-cultural early childhood teaching experience. *Australian Journal of Educational & Developmental Psychology*, 7, pp. 11–21. Available at https://www.newcastle.edu.au/__data/assets/pdf_file/0017/100349/v7-brownlee-chak.pdf (Accessed 21 August 2019).

Bryman, A. (2006). Paradigm peace and implications for quality. *International Journal of Social Research Methodology and Practice*, 9(2), pp.111-126. https://doi.org/10.1080/13645570600595280

Buabeng-Andoh. C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 8(1), pp. 136-155. Available at https://files.eric.ed.gov/fulltext/EJ1084227.pdf (Accessed 15 October 2019).

Butler-Adam, J. (2018). The Fourth Industrial Revolution and education. *South African Journal of Science*, Volume 114(5-6).

http://dx.doi.org/10.17159/sajs.2018/a0271

Casteel, A., & Bridier, N.L. (2021). Describing populations and samples in doctoral student research. *International Journal of Doctoral Studies*, 16, pp. 392 – 362. Available at https://doi.org/10.28945/4766 (Accessed 11 February 2022).

Cavas, B., Cavas, P, Karaoglan, B. & Kisla, T. (2009). A study on Science Teachers' attitude towards Information and Communication Technologies in Education. *Turkish Online Journal of Educational Technology*, 8(2), pp. 20-32. Available at http://www.tojet.net/articles/v8i2/822.pdf (Accessed 15 November 2019).

Chan, K.K.H., Rollnick, M., & Gess-Newsome, J. (2019). A Grand Rubric for Measuring Science Teachers' Pedagogical Content Knowledge. In A. Hume, R. Cooper & A. Borowski (Eds.), *Repositioning Pedagogical Content Knowledge in Teachers' Knowledge for Teaching Science* (pp. 251-269). Springer, Singapore. https://doi.org/10.1007/978-981-13-5898-2_11

ChanLin, L.J., Hong, J.C., Horng, J.S., Chang, S.H., & Chu, H.C. (2006). Factors influencing technology integration in teaching: A Taiwanese perspective. *Innovations in Education and Teaching International*, 43(1), pp. 57–68. https://doi.org/10.1080/14703290500467467

Chau, P.Y. (1996). An empirical assessment of a modified technology acceptance model. *Journal of management information systems*, 13(2), pp. 185-204. https://doi.org/10.1080/07421222.1996.11518128

Check J., & Schutt R.K. (2012). Survey research. In J. Check and R.K. Schutt, (Eds.), *Research methods in education* (pp. 159-185). Thousand Oaks, CA: Sage Publications.

Chen, C.H. (2008). Why Do Teachers Not Practice What They Believe Regarding Technology Integration? *Journal of Educational Research*, Volume 102(1), pp. 65-75. https://doi.org/10.3200/JOER.102.1.65-75

Chigona, A., & Chigona, W. (2010). An investigation of factors affecting the use of ICT for teaching in the Western Cape schools. 18th European Conference on

Information Systems, ECIS 2010. Available at https://aisel.aisnet.org/ecis2010/61/ (Accessed 23 March 2019).

Chigona, A., Chigona, W., Kausa, M., & Kayongo, P. (2010). An empirical survey on domestication of ICT in schools, in disadvantaged communities in South Africa. *International Journal of Education and Development Using ICT*, Volume 6(2), pp. 21-32. Available at https://eric.ed.gov/?id=EJ1085003 (Accessed 23 March 2019).

Chikasa, S., Ntuli, M., & Sundarjee, R. (2014). ICT integration in teaching: An uncomfortable zone for teachers: A case of schools in Johannesburg. *Education as Change*, 18(1), pp. 137-150. https://doi.org/10.1080/16823206.2013.847013

Chisholm, L. (2000). *A South African Curriculum for the Twenty First Century: Report of The Review Committee On Curriculum 2005*. Pretoria: National Department of Education.

Chitungo, S.K., & Munongo, S. (2013). Extending the Technology Acceptance Model to Mobile Banking Adoption in Rural Zimbabwe. *Journal of Business Administration and Education*, 3(1), pp. 51–79. Available at https://www.infinitypress.info/index.php/jbae/article/view/100 (Accessed 14 April 2018).

Chuttur, M.Y. (2009). Overview of the technology acceptance model: Origins, Developments and Future directions. *Sprouts: Working Papers on information Systems*, 9(37), pp. 1–21. Available at: https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1289&context=sprouts_all (Accessed 18 December 2017).

Clarkson, B., & Oliver, R. (2002). *A Typology for Identifying Teachers' Progress in ICT Uptake.* World Conference on Educational Multimedia, Hypermedia and Telecommunications, Chesapeake, VA: AACE. Available at https://ro.ecu.edu.au/cgi/viewcontent.cgi?referer=&httpsredir=1&article=4904&context=ecuworks (Accessed 15 March 2020).

Clausen, J.M. (2007). Beginning teachers' technology use: First-year teachers' development and the institutional context's affect on new teachers' instructional technology use with learners. *Journal of Research on Technology in Education,* 39(3), pp. 245-261. https://doi.org/10.1080/15391523.2007.10782482

Cole, K., Simkins, M., & Penuel, W. (2002). Learning to teach with technology: Strategies for in-service professional development. *Journal of Technology and Teacher Education*, 10(3), pp. 431–455. Available at https://www.learntechlib.org/primary/p/26282/ (Accessed 23 October 2018).

Conner, M., & Armitage, C.J. (1998). Extending the theory of planned behaviour: a review and avenues for further research. *Journal of Applied Social Psychology*, 28(15), pp. 1429–1464. https://doi.org/10.1111/j.1559-1816.1998.tb01685.x

Coppieters, P. (2005). Turning schools into learning organizations. *European Journal of Teacher Education*, 28(2), pp. 129-139. https://doi.org/10.1080/02619760500093131

Costa, F. (2016). Curricular development and ICT: From technological deficit to methodological deficit. In A. Moreira, A. Szucs, & I. Mázár (Eds), Proceedings of the European Distance and E-learningNetwork annual conference. Re-imaging learning environments (pp. 435–447). Budapest: European Distance and E-learning Network.

Cox, M., Abbott, C., Webb, M., Blakeley, B., Beauchamp, T., & Rhodes, V. (2004). A Review of the Research Literature Relating to ICT and Attainment. Available at https://www02.core.ac.uk/download/pdf/4151887.pdf (Accessed 15 December 2017).

Cox, M., Preston, C. & Cox, K. (1999). What Motivates Teachers to Use ICT? *Education Online.*

Cradler, J., Freeman, M., Cradler, R., & McNabb, M. (2002). Research implications for preparing teachers to use technology. *Learning and leading with technology*, 30(1), pp. 50-57. Available at https://silo.tips/download/research-implications-for-preparing-teachers-to-use-technology (Accessed 3 January 2018).

Crandall, D.P., Loucks-Horsley, S., Bauchner, J.E., Schmidt, W.B., Eiseman, J.W., Cox, P.L., Miles, M.B., Huberman, A.M., Taylor, B.L., Goldberg, J.A., Shive, G., Thompson, C.L., & Taylor, J.A. (1982). *People, Policies, and Practices: examining the chain of school improvement.* Andover, MA: The NETWORK, Inc.

Crawford, P. (2004). I follow the blue. A primary teacher and the impact of packaged curricula. *Early Childhood Education Journal*, 32, pp. 205–210. https://doi.org/10.1023/B:ECEJ.0000048974.70769.35

Creswell, J.W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, California: Sage Publications.

Creswell, J.W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*, 4th ed. Upper Saddle River, NJ: Pearson Education.

Creswell, J.W. (2014). Research design: *Qualitative, quantitative, and mixed methods approaches,* 4th ed. California: Sage publications, Inc.

Creswell, J.W., & Plano-Clark, V.L. (2011). *Designing and conducting mixed methods research*, 2nd ed. Thousand Oaks, CA: SAGE Publications, Inc.

Crouch, L., & Perry, H. (2003). Educators. In HSRC, *Human Resource Development Review 2003* (chapter 21). Pretoria: HSRC.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge: Harvard University Press.

d'Astous, A., Colbert, F., & Montpetit, D. (2005). Music Piracy on the Web- "How Effective are Anti-Piracy Arguments? Evidence from the Theory of Planned Behaviour. *Journal of Consumer Policy*, 28(3), pp. 289-310.

Davidson, M.R., Fields, M.K., & Yang, J. (2009). A randomized trial study of a preschool literacy curriculum: The importance of implementation. *Journal of*

Research on Educational Effectiveness, 2(3), pp. 177-208. https://doi.org/10.1080/19345740902770028

Davis, A. (2004). *Finding proof of learning in a one-to-one computing classroom.* Courtenay, BC: Connections Publishing.

Davis, F.D. (1985). A technology acceptance model for empirically testing new end-user information systems: theory and results. Unpublished Ph.D., MIT Sloan School of Management, Cambridge, MA. Available at http://hdl.handle.net/1721.1/15192 (Accessed 15 April 2018).

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), pp. 319–340. https://doi.org/10.2307/249008

Davis, F.D. (1993). User acceptance of information technology: System characteristics, user perceptions and behavioural impacts. *International Journal of Man–Machine Studies*, 38, pp. 475–487.

Davis, F.D., Bagozzi, R.P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science*, 35(8), pp. 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Davis, N. (2016). What is the fourth industrial revolution? Available at: https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/(Accessed 16 July 2020).

Davis, N., Preston, C., & Sahin, I. (2009). Training teachers to use new technologies impacts multiple ecologies: Evidence from national initiative. *British Journal of Education Technology*, 40(5), pp. 861-878. https://doi.org/10.1111/j.1467-8535.2008.00875.x

De Smet, C., Bourgonjon, J., De Wever, B., Schellens, T., & Valcke, M. (2012). Researching instructional use and the technology acceptance of learning management systems by secondary school teachers. *Computers & Education*, 58(2), pp. 688–696. https://doi.org/10.1016/j.compedu.2011.09.013

Debois, S. (2016). 9 Advantages and Disadvantages of Questionnaires. Available at: https://surveyanyplace.com/questionnaire-pros-and-cons/ (Accessed 24 May 2018)

Dejonckheere, M., & Vaughn, L. (2019). Semi structured interviewing in primary care research: a balance of relationship and rigour. *BMJ Journals*. Available at: https://fmch.bmj.com/content/7/2/e000057#article-bottom (Accessed 18 February 2022).

Demetriadis, S., Barbas, A., Molohides, A., Palaigeorgiou, G., Psillos, D., & Vlahavas, I. (2002). 'Cultures in negotiation': Teacher's acceptance/ resistance attitudes considering the infusion of technology into schools. *Computers & Education*, 41(1), pp. 19-37. https://doi.org/10.1016/S0360-1315(03)00012-5

Deng, F., Chai, C.S., Tsai, C.C., & Lee, M.H. (2014). The relationships among Chinese practicing teachers' epistemic beliefs, pedagogical beliefs and their beliefs about the use of ICT. *Journal of Educational Technology & Society*, 17(2), pp. 245–256. Available at https://www.jstor.org/stable/jeductechsoci.17.2.245 (Accessed 20 June 2017).

DENI, (1997). A strategy for education technology in Northern Ireland. Bangor: Department of Education for Northern Ireland. https://doi.org/10.1108/10650740610639697

Denscombe, M. (2008). Communities of Practice: A Research Paradigm for the Mixed Methods Approach**.** *Journal of Mixed Methods Research*, 2(3), pp. 270-283. https://doi.org/10.1177/1558689808316807

Denzin, N.K., & Lincoln, Y.S. (2011). *The SAGE handbook of qualitative research*.

Thousand Oaks, California: SAGE.

Department of Education. (2004). Draft White Paper on e-Education. Pretoria. (Government Gazette, Notice 1869 of 2004). Available at: https://www.gov.za/sites/default/files/gcis_document/201409/e-education1.pdf (Accessed 20 May 2019).

Department of Basic Education. (2012). Guidelines for schools: ICT Hardware Specifications. Pretoria: Government Printers. Available at http://www.thutong.doe.gov.za/ResourceDownload.aspx?id=47447&userid=-1 (Accessed 15 July 2018).

Department of Basic Education. (2015). Action Plan to 2019: Towards the Realisation of Schooling 2030. Pretoria: Department of Basic Education. Available at: https://www.education.gov.za/Portals/0/Documents/Publications/Action%20Plan%202019.pdf (Accessed 10 August 2021).

Dewey, J. (1986). *The later works of John Dewey: 8, 1925–1953: Essays and how we think* (Rev. Ed.: J.A. Boydston, Ed.). Carbondale: Southern Illinois University Press. (Original work published 1933).

Dexter, S. (2008). Leadership for IT in Schools. In J. Voogt & G. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education*, *2* (pp. 543-554). New York: Springer.

Dillman, D.A., Smyth, J.D., & Christian, L.M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method.* Hoboken, NJ.: John Wiley & Sons, Inc.

Dillon, A., & Morris, M.G. (1996). User acceptance of new information technology: theories and models. Available at http://hdl.handle.net/10150/105584 (Accessed 20 November 2018).

Dishaw, M.T., & Strong, D.M. (1999). Extending the technology acceptance model with task-technology fit constructs. *Information and Management*, Volume 36(1), pp. 9–21. https://doi.org/10.1016/S0378-7206(98)00101-3

Department of Education (2004). White Paper on e-Education. Notice 1869 of 2004, published. Available at https://www.gov.za/documents/white-paper-e-education-transforming-learning-and-teaching-through-information-and (Accessed 27 March 2020).

Donnelly, D., McGarr, O., & O'Reilly, J. (2011). A framework for teachers' integration of ICT into their classroom practice. *Computers and Education*, 57(2), pp. 1469–1483. https://doi.org/10.1016/j.compedu.2011.02.014

Doppen, F. (2007). Pre-service social studies teacher's perceptions of high-standards, high-stakes. *International Journal of Social Education*, 21(2), pp. 18–45. Available at https://files.eric.ed.gov/fulltext/EJ782142.pdf (Accessed 14 April 2018).

Dorner, H., & Kumar, S. (2016). Online Collaborative Mentoring for Technology Integration in Pre-Service Teacher Education. *TechTrends*, 60, pp. 48–55. https://doi.org/10.1007/s11528-015-0016-1

Doyle, J.K. (2004). Introduction to interviewing techniques. In D.W. Wood (Ed.), *Handbook for IQP Advisors and Students*. Worcester, MA: Worcester Polytechnic Institute.

Drossel, K., Eickelmann, B., & Gerick, J. (2016). Predictors of teachers' use of ICT in school the relevance of school characteristics, teachers' attitudes and teacher collaboration. *Education Information Technology*, 22, pp. 551-571. https://doi.org/10.1007/s10639-016-9476-y

Drury, R., Homewood, K., & Randall, S. (2011). Less is more: the potential of qualitative approaches in conservation research. *Animal Conservation*, 14(1), pp. 18-24. http://dx.doi.org/10.1111/j.1469-1795.2010.00375.x

Du Plessis, A. & Webb, P. (2012). Teachers' perception about their own and their schools' readiness for computer implementation: A South African Case Study.

The Turkish Online Journal of Educational Technology, 11(3), pp. 312-325.

Du Toit, A.D. (2004). Social Exclusion' Discourse and Chronic Poverty: A South African Case Study. *Development and Change*, 35(5), pp. 987-1010. https://doi.org/10.1111/j.1467-7660.2004.00389.x

Du Toit, I. (2005). The Effect of ICT curriculum support on the measured skills levels of learners of two sub-project of the Khanya Project. Available at: https://www.researchgate.net/publication/229003129_The_effect_of_ICT_curriculum_support_on_the_measured_skills_levels_of_learners_of_two_sub-projects_of_the_Khanya_project (Accessed 15 June 2017).

Duyck, P., Pynoo, B., Devolder, P., Adang, L., Vercruysse, J., & Voet, T. (2008). Do hospital physicians really want to go digital? Acceptance of a picture archiving and communication system in a university hospital. *RöFo,* Volume 180(7), pp. 631–638. https://doi.org/10.1055/s-2008-1027344

Earle, R. (2002). The integration of instructional technology into public education: Promises and challenges. *Education Technology Magazine*, 42(1), pp. 5-13. Available at https://www.jstor.org/stable/44428716 (Accessed 15 April 2018).

Eickelmann, B., Bos, W., Gerick, J., & Kahnert, J. (2014). Anlage, Durchführung und Instrumentierung von ICILS 2013 [Execusion and Instruments of ICILS 2013]. In W. Bos, B. Eickelmann, J. Gerick, F. Goldhammer, H. Schaumburg, K. Schwippert, M. Senkbeil, R. Schulz-Zander, & H. Wendt (Eds.), *ICILS 2013. Computer- und informationsbezogene Kompetenzen von Schülerinnen und Schülern in der 8. Jahrgangsstufe im internationalen Vergleich* (pp. 43–81). Waxmann: Münster. Available at https://www.pedocs.de/volltexte/2015/11459/pdf/ICILS_2013_Berichtsband.pdf (Accessed 17 March 2019).

El-Deghaidy, H., & Nouby, A. (2008). Effectiveness of a blended e-learning cooperative approach in an Egyptian teacher education programme. *Computers & Education*, 51, pp. 988-1006. https://doi.org/10.1016/j.compedu.2007.10.001

Engineering News. (2015). ‘Appropriate use’ of ICT in classrooms seen as helping turn SA’s education tide. Available at: https://www.engineeringnews.co.za/print-version/appropriate-use-of-ict-in-classrooms-seen-as-helping-turn-sas-education-tide-2015-11-13 (Accessed 13 December 2019).

Erdogdu, F., & Erdogdu, E. (2015). The impact of access to ICT, student background and school/home environment on academic success of students in Turkey: An international comparative analysis. *Computers & Education*, 82, pp. 26-49. https://doi.org/10.1016/j.compedu.2014.10.023

Erdogdu, F., & Erdogdu, E. (2015). The impact of access to ICT, student background and school/home environment on academic success of students in Turkey: An international comparative analysis. *Computers & Education*, 82, pp. 26-49. http://dx.doi.org/10.1016/j.compedu.2014.10.023

Ertmer, P. (1999). Addressing first-and second-order barriers to change: strategies for technology integration. *Educational Technology Research and Development*, 47(4), pp. 47-61. https://doi.org/10.1007/BF02299597

Ertmer, P., Conklin, D., Lewandowski, J., Osika, E., Selo, M. & Wignall, E. (2003). Increasing preservice teachers’ capacity for technology integration through use of electronics models. *Teacher Education Quarterly*, 30(1), pp. 95–112. Available at https://www.jstor.org/stable/23478427 (Accessed 1 November 2017).

Ertmer, P.A. (2001). Responsive Instructional Design: Scaffolding the Adoption and Change Process. *Educational Technology*, 41(6), pp. 33-38. Available at https://files.eric.ed.gov/fulltext/ED455769.pdf (Accessed 17 December 2017).

Ertmer, P.A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development*, 53(4), pp. 25–39. https://doi.org/10.1007/BF02504683

Ertmer, P.A., & Ottenbreit-Leftwich, A.T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on*

Technology in Education, 42(3), pp. 255–284. https://doi.org/10.1080/15391523.2010.10782551

Ertmer, P.A., Ottenbreit-Leftwich, A., & Tondeur, J. (2015). Teacher beliefs and uses of technology to support 21st century teaching and learning. In H.R. Fives & M.Gill (Eds.), *International handbook of research on teacher beliefs* (pp. 403–418). New York: Routledge, Taylor & Francis.

Ertmer, P.A., Ottenbreit-Leftwich, A., & York, C. (2006). Exemplary technology-using teachers: Perceptions of factors influencing success. *Journal of Computing in Teacher Education*, 23(2), pp. 55–61. Available at https://www.tandfonline.com/doi/abs/10.1080/10402454.2006.10784561 (Accessed 3 January 2018).

Ertmer, P.A., Ottenbreit-Leftwich, A.T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, 59(2), pp. 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Eryilmaz, A. (2015). The effectiveness of blended learning environments. *Contemporary Issues In Education Research*, 8(4), pp. 251-256. DOI https://doi.org/10.19030/cier.v8i4.9433

Esfijani, A., & Zamani, B.E. (2020). Factors influencing teachers' utilisation of ICT: the role of in-service training courses and access. Research in learning technology, 28. Available at https://journal.alt.ac.uk/index.php/rlt/article/view/2313/2692 (Accessed 19 February 2022).

Eze, R.I., & Olusola, E. (2013). The teachers and the use of ICT for professional development. International Conference on ICT for Africa. Available at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.674.3880&rep=rep1&type=pdf (Accessed 3 January 2019).

Falko, F., Sniehotta, J.P., & Vera, A. (2014). Time to retire the theory of planned behaviour. *Health Psychology Review*, 8(1), pp. 1-7. https://doi.org/10.1080/17437199.2013.869710

Farn, C.K., Fan, Y.W., & Chen, C.D. (2006). Predicting electronic toll collection service adoption: An integration of the technology acceptance model and the theory of planned behaviour. In J. Bhattachacharya (Ed.), *Technology in government* (pp. 145–154). New Delhi: GIFT Publishing.

Farrukh, S., & Singh, S.P. (2014). Teachers' attitude towards use of ICT in technical and non-technical institutes. *Journal of Educational and Social Research*, 4(7), pp. 153-160. Doi:10.5901/jesr.2014.v4n7p153

Feist, L. (2003). Removing barriers to professional development. *T.H.E. Journal*, 30(11), pp. 30-36. Available at https://thejournal.com/Articles/2003/06/01/Removing-Barriers-to-Professional-Development.aspx (Accessed 27 December 2017).

Field, A. (2009). *Discovering Statistics Using SPSS: (and sex and drugs and rock 'n' roll)*, 3rd ed. Los Angeles: SAGE Publications.

Fink, A. (2014). *Conducting Research Literature Reviews: From the Internet to Paper,* 4th ed. Thousand Oaks, CA: SAGE.

Fish, D., Allie, S., Pelaez, N., & Anderson, T. (2017). A cross-cultural comparison of high school students' responses to a science centre show on the physics of sound in South Africa. *Public Understanding of Science,* V 26(7), pp. 806-814. https://doi.org/10.1177/0963662516642725

Fishbein, M. (1967). *Readings in attitude theory and measurement*. New York: Wiley.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behaviour: An introduction to theory and research*. Reading, MA: ADDISON Wesley.

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behaviour: The reasoned action approach.* New York, NY: Psychology Press.

Fishman, B.J., & Zhang, B.H. (2003). Planning for technology: The link between intentions and use. *Educational Technology*, 43(4), pp. 14–18. Available at https://www.jstor.org/stable/44428843 (Accessed 17 August 2017).

Fives, H., & Buehl, M.M. (2012). Individual Differences and Cultural and Contextual Factors. *APA Educational Psychology Handbook*, *2*, (pp. 471–499). Available at: http://www.montclair.edu/profilepages/media/1391/user/Fives_&_Buehl_2012.pdf (Accessed 25 October 2017).

Fives, H., & Gill, M.G. (2015). *International handbook of research on teachers' beliefs*. New York: Routledge, Taylor & Francis.

Fives, H., Hamman, D., & Olivarez, A. (2007). Does burnout begin with student teaching? Analyzing efficacy, burnout and support during the student-teaching semester. *Teaching and Teacher Education*, 23, pp. 916–934. http://dx.doi.org/10.1016/j.tate.2006.03.013

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12, pp. 219-245. https://doi.org/10.1177/1077800405284363

Ford, M., & Botha, A. (2010). Pragmatic framework for integrating ICT into education in South Africa. IST Africa, 2010. Available at https://researchspace.csir.co.za/dspace/handle/10204/4098 (Accessed 14 April 2018).

Forkosh-Baruch, A., Nachmias, R., Mioduser, D., & Tubin, D. (2005). "Islands of Innovation" and "School-Wide Implementation": Two Patterns of ICT-based Pedagogical Innovations in Schools. *Human Technology*, 1(2), pp. 202-215. Available at https://jyx.jyu.fi/handle/123456789/20182?locale-attribute=en

(Accessed 17 November 2017).

Fossheim, H.J. (2015). The Norwegian National Research Ethics Committee: Confidentiality. Available at: https://www.etikkom.no/en/library/topics/data-protection-and-responsibility-concerning-the-individual/confidentiality/ (Accessed 28 February 2017).

Frazier, M., & Bailey, G.D. (2004). *The technology coordinator's handbook*. Washington: ISTE.

Freshwater, D. (2007). Reading mixed methods for criticism. *Journal of Mixed Methods Research*, 1(2), pp.134-146. https://doi.org/10.1177/1558689806298578

Fu, J.S. (2013). ICT in education: A critical literature review and its implications. *International Journal of Education and Development using Information and Communication Technology (IJEDICT*), 9(1), pp. 112-125. Available at https://files.eric.ed.gov/fulltext/EJ1182651.pdf (Accessed 18 May 2018).

Fuchs, T., & Woessman, I. (2004). Computers and Student Learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School, CESifo Working Paper. No. 1321.November. Munich. Available at https://www.cesifo.org/DocDL/cesifo1_wp1321.pdf (Accessed 17 January 2018).

Fullan, M., & Langworthy, M. (2013). Towards a new end: New pedagogies for deep learning. Seattle Washington: Collaborative impact. Available at http://www.newpedagogies.nl/images/towards_a_new_end.pdf (Accessed 18 April 2019).

Galanouli, D., Murphy, C., & Gardner, J. (2004). Teachers' perceptions of the effectiveness of ICT-competence training. *Computers & Education*, 43(1-2), pp. 63-79. https://doi.org/10.1016/j.compedu.2003.12.005

George, A., & Sanders, M. (2017). Evaluating the potential of teacher-designed technology-based tasks for meaningful learning: Identifying needs for professional development. *Education and Information technology*, 22(6), pp. 2871–2895. https://doi.org/10.1007/s10639-017-9609-y

George, J.F. (2004). The theory of planned behaviour and internet purchasing. *Internet Research*, 14(3), pp. 198–212. https://doi.org/10.1108/10662240410542634

Gil-Flores, J., Rodríguez-Santero, J., & Rodríguez-Santero, J. (2017). Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure. *Computers in Human Behaviour*, 68, pp. 441–449. https://doi.org/10.1016/j.chb.2016.11.057

Gleichmann, N. (2020). Paired vs Unpaired T-Test Difference, Assumptions and Hypotheses. Technology Networks, [Online]. Available at https://www.technologynetworks.com/informatics/articles/paired-vs-unpaired-t-test-differences-assumptions-and-hypotheses-330826 (Accessed 29 June 2021).

Goktas, Y., Gedik, N & Baydas, O. (2013). Enablers and barriers to the use of ICT in primary schools in Turkey: A comparative study of 2005-2011. *Computers & Education*, 68, pp. 211-222. https://doi.org/10.1016/j.compedu.2013.05.002

Goswami, A., & Dutta, S. (2016). Gender Differences in Technology Usage — A Literature Review. *Open Journal of Business and Management*, 4(1). Available at: https://www.scirp.org/journal/paperinformation.aspx?paperid=62732 (Accessed 15 September 2021).

Govender, D. W. (2012) A model to predict educators' attitudes towards technology and thus technology adoption. *Africa Education Review*, 9(3), pp. 548-568. https://doi.org/10.1080/18146627.2012.741101

Govender, D., & Govender, I. (2009). The relationship between information and communication technology (ICT) integration and teachers' self-efficacy beliefs about ICT. *Education as Change*, 13(1), pp. 153-165.

https://doi.org/10.1080/16823200902943346

Graham, C.R., Allen, S., & Ure, D. (2003). *Blended learning environments*: A review of the research literature. Unpublished manuscript, Provo, UT. Available at: https://www.scirp.org/(S(czeh2tfqyw2orz553k1w0r45))/reference/ReferencesPapers.aspx?ReferenceID=2143741 (Accessed 23 December 2017).

Greene, J. C. (2007). *Mixed methods in social inquiry*. San Francisco, CA: John Wiley & Sons.

Greene, J.C., Caracelli, V.J., & Graham, W.F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, 11(3), pp. 255–274. https://doi.org/10.3102/01623737011003255

Gu, X., Zhu, Y. & Guo, X (2013). Meeting the "Digital Natives": Understanding the Acceptance of Technology in Classrooms. *Educational Technology & Society*, 16(1), pp. 392–402. Available at https://www.jstor.org/stable/jeductechsoci.16.1.392 (Accessed 18 May 2018).

Guba, E.C. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, Volume 29, pp. 75-91. https://doi.org/10.1007/BF02766777

Gudmundsdottir, G.B. (2010). When does ICT support education in South Africa? The importance of teachers' capabilities and the relevance of language. *Information Technology for Development,* 16(3), pp. 174-190. https://doi.org/10.1080/02681102.2010.498409

Guskey, T.R. (1989). Attitude and perceptual change in teachers. *International Journal of Educational Research*, 13(4), pp. 439-453. https://doi.org/10.1016/0883-0355(89)90039-6

Guskey, T.R. (2002). Professional Development and Teacher Change. *Teachers and Teaching: theory and practice*, 8(3/4), pp. 381-391, https://doi.org/10.1080/135406002100000512

Guskey, T.R., & Huberman, M. (1995). P*rofessional Development in Education: new paradigms and practices*. New York: Teachers College Press.

Guthrie, G., (2018). Classroom Change in Developing Countries*: From Progressive Cage to Formalistic Frame*, Routledge.

Guzman, A., & Nussbaum, M. (2009). Teaching competencies for technology integration in the classroom. *Journal of Computer Assisted Learning*, 25(5), pp. 453-469. https://doi.org/10.1111/j.1365-2729.2009.00322.x

Hamat, A., & Embi, M. (2010). Constructivism in the design of online learning tools. *European Journal of Educational Studies*, 2(3), pp. 237–246. https://www.researchgate.net/publication/229040545_CONSTRUCTIVISM_IN_THE_DESIGN_OF_ONLINE_LEARNING_TOOLS (Accessed 20 April 2019).

Hamilton, E.R., Rosenberg, J.M., & Akcaoglu, M. (2016). The Substitution Augmentation Modification Redefinition (SAMR) Model: a Critical Review and Suggestions for its Use. *TechTrends,* 60, pp. 433–441. https://doi.org/10.1007/s11528-016-0091-y

Harriss, D. J., MacSween, A., & Atkinson, G. (2020). Ethical Standards in Sport and Exercise Science Research: 2020 Update. *International Journal of Sports Medicine*, pp. 813-817.

Hart, S.N., & Laher, S. (2015). Perceived usefulness and culture as predictors of teachers' attitudes towards educational technology in South Africa. *South African Journal of Education*, 35(4), pp. 1-13. http://dx.doi.org/10.15700/saje.v35n4a1180

Harvey, J., & Purnell, S. (1995). Technology and teacher professional development. Available at https://files.eric.ed.gov/fulltext/ED393831.pdf (Accessed 3

November 2017).

Hawkins, J., & MacMillan, K. (1993). So what are teachers doing with this stuff? *Electronic Learning*, 13(2), pp. 26.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. *Evidence Based Nursing*, 18(3), pp. 66–67. http://dx.doi.org/10.1136/eb-2015-102129

Heick, T. (2019). 4 Phases of Inquiry-Based Learning: A Guide for Teachers. [Online] Available at: https://www.teachthought.com/pedagogy/4-phases-inquiry-based-learning-guide-teachers/ (Accessed 21 April 2020).

Hennessy, M., Bleakley, A., & Fishbein, M. (2012). Measurement models for reasoned action theory. *Annals of the American Academy of Political and Social Science*, 640(1), pp. 42–57. https://doi.org/10.1177/0002716211424709

Hennessy, S., Harrison, D., & Wamakote, L. (2010). Teacher Factors influencing Classroom use of ICT in Sub-Sahara Africa. *Itupale Journal of African Studies*, 2, pp. 39-54. Available at https://www.researchgate.net/publication/228399541_Teacher_factors_influencing_classroom_use_of_ICT_in_Sub-Saharan_Africa (Accessed 19 May 2018).

Hermans, R., Tondeur, J., Van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. *Computers & Education*, 51(4), pp. 1499–1509. https://doi.org/10.1016/j.compedu.2008.02.001

Herring, M.C., Koehler, M.J., & Mishra, P. (2016). *Handbook of technological pedagogical content knowledge (TPACK) for educators*. New York: Routledge.

Herselman, M.E. (2003). ICT in Rural Areas in South Africa: Various Case Studies. *InSITE*, 3. Available at: https://doi.org/10.28945/2680 (Accessed 17 May 2018).

Hew, K., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational*

Technology, Research and Development, 55, pp. 223–252. https://doi.org/10.1007/s11423-006-9022-5

Hilton, J.T. (2016). A Case Study of the Application of SAMR and TPACK for Reflection on Technology Integration into Two Social Studies Classrooms. *The Social Studies*, 107(2), pp. 68-73. https://doi.org/10.1080/00377996.2015.1124376

Hinostroza, J.E., Ibieta, A.I., Claro, M., and Labbé, C. (2016). Characterisation of teachers' use of computers and Internet inside and outside the classroom: The need to focus on the quality. *Educ Inf Technol,* 21, 1595–1610. https://doi.org/10.1007/s10639-015-9404-6

Ho, V., Nakamoria, Y., Ho, T., & Ho, S. (2013). Study on a model for teacher professional development in Vietnam based on knowledge management. Proceedings of the 57th Annual Meeting of the ISSS, Hai-Phong, Vietnam. Available at https://journals.isss.org/index.php/proceedings57th/article/view/2020 (Accessed 15 April 2019).

Hockly, N. (2013). Technology for the language teacher: Mobile learning. *ELT Journal*, 67(1), pp. 80–84. http://dx.doi.org/10.1093/elt/ccs064

Hokanson, B., & Hooper, S. (2000). Computers as cognitive media: examining the potential of computers in education. *Computers and Human Behaviour*, 16(5), pp. 537-552. https://doi.org/10.1016/S0747-5632(00)00016-9

Holmqvist, M. (2018). Lack of qualified teachers: A global challenge for future knowledge development. Available at: https://www.intechopen.com/books/teacher-education-in-the-21st-century/lack-of-qualified-teachers-a-global-challenge-for-future-knowledge-development (Accessed 4 August 2020).

Hopp, T.M. (2013). Subjective norms as a driver of mass communication students: Intentions to adopt new media production technologies. *Journalism and Mass*

Communication Educator, 68(4), pp. 348–364. https://doi.org/10.1177/1077695813506993

Houghton, C., Casey, D., Shaw, D., & Murphy, K. (2013). Rigour in qualitative case study research. *Nurse Researcher*, 20(4), pp. 12–17. http://dx.doi.org/10.7748/nr2013.03.20.4.12.e326

Howe, K.R. (1988). Against the quantitative-qualitative incompatibility thesis or dogmas die hard. *Educational Researcher*, 17(8), pp. 10-16. https://doi.org/10.3102/0013189X017008010

Howie, S.J., & Blignaut, A. (2009). South Africa's readiness to integrate ICT into Mathematics and Science pedagogy in secondary schools. *Educ Inf Technol,* 14(4), pp. 345–363. https://doi.org/10.1007/s10639-009-9105-0

Hsu, S. (2014). Teacher's background and ICT uses at schools in Taiwan. Available at: Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.422.3508&rep=rep1&type=pdf(Accessed 29 October 2018).

Huang, H.M., & Liaw, S.S. (2005). Exploring user's attitudes and intentions toward the web as a survey tool. *Computers in Human Behaviour*, Volume 21(5), pp. 729-743. https://doi.org/10.1016/j.chb.2004.02.020

Huberman, M. (1992). Teacher development and instructional mastery. In A. Hargreaves & M.G. Fullan (Eds.), *Understand Teacher Development* (pp. 122-142). New York: Teachers College Press.

Huberman, M., & Crandall, D. (1983). *People, Policies and Practice: examining the chain of school improvement, 9, Implications for Action: a study of dissemination efforts supporting school improvement.* Andover, MA.: The NETWORK Inc.

Huberman, M., & Miles, M.B. (1984). *Innovation up Close: how school improvement works.* New York: Plenum.

Humes, V. (2017). The Impact of TPACK, SAMR, and Teacher Effectiveness on Student Academic Growth in Eighth Grade Language Art and Mathematics. Unpublished D.Ed., Youngstown State University. Available at http://hdl.handle.net/1989/13013 (Accessed 22 November 2019)

Hunde, A.B., & Tacconi, G. (2013). Pulling and pushing forces for ICT use in initial teacher preparation for secondary schools. *US-China Education Review*, 3(10, pp. 707-721). Available at https://iris.univr.it/retrieve/handle/11562/630752/6801/Hunde%20Tacconi%20-%20Pulling%20and%20Pushing%20Forces%20for%20ICT%20Use%20-%202013.pdf (Accessed 19 May 2018).

Hwang, D.J., Yang, H., & Kim, H. (2010). E-Learning in the Republic of Korea. UNESCO. Available at: https://iite.unesco.org/publications/3214677/ **Error! Hyperlink reference not valid.**(Accessed 22 November 2019).

Iivari, J., & Venable, J. (2009). Action research and design science research – Seemingly similar but decisively dissimilar, 17th European Conference on Information Systems, Verona

Inan, F., & Lowther, D. (2010b). Laptops in the K-12 classrooms: Exploring factors impacting instructional use. *Computers & Education*, 55(3), pp. 937–944. https://doi.org/10.1016/j.compedu.2010.04.004Inan

Inserra, A., & Short, T. (2012). An analysis of high school math, science, social studies, English, and foreign language teachers' implementation of one-to-one computing and their pedagogical practices. *Journal of Educational Technology Systems*, 41(2), pp. 145–169. https://doi.org/10.2190/ET.41.2.d

International Society for Technology in Education. (2015). ISTE standards. Available at: iste.org/iste-standards (Accessed 25 May 2018).

Isikoglu, N. (2008). The effects of a teaching methods course on early childhood preservice teachers' beliefs. *Journal of Early Childhood Teacher Education*, 29(3), pp. 190–203. https://doi.org/10.1080/10901020802275260

Jackson, C.M., Chow, S., & Leitch, R.A. (1997). Toward an understanding of the behavioural intentions to use an information system. *Decision Sciences*, 28(2), pp. 357–389. https://doi.org/10.1111/j.1540-5915.1997.tb01315.x

Jackson, K.M., & Marriott, C. (2012). The Interaction of Principal and Teacher Instructional Influence as a Measure of Leadership as an Organizational Quality. *Educational Administration Quarterly*, 48(2), pp. 230-258. https://doi.org/10.1177/0013161x11432925

Jacobs, L. (2018). Current status with regard to ICT Integration in teaching and learning in Free State schools. Available at https://www.researchgate.net/publication/341930486_CURRENT_STATUS_WITH_REGARD_TO_ICT_INTEGRATION_IN_TEACHING_AND_LEARNING_IN_FREE_STATE_SCHOOLS_EXECUTIVE_SUMMARY_Commissioned_by_VVOB_and_in_collaboration_with_the_Free_State_Department_of_Education/link/5ed9e4c74585152945370c14/download (Accessed 27 April 2020).

Jebeile, S.H., & Abeysekera, I. (2010). The spread of ICT innovation in Accounting Education. *International Journal of teaching and learning in higher education*, 22(2), pp. 158-168. Available at https://files.eric.ed.gov/fulltext/EJ930149.pdf (Accessed 23 August 2019).

Johnson, B., & Gray, R. (2010). A history of philosophical and theoretical issues for mixed-method research. In *SAGE handbook of mixed methods in social & behavioral research* (pp. 69-94). SAGE Publications, Inc. Available at https://www-doi-org.ufs.idm.oclc.org/10.4135/9781506335193 (Accessed 23 May 2018).

Johnson, R.B., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Who's Time Has Come. *Educational Researcher*, Volume 33(7), pp. 14-26. Available at: http://www.jstor.org/stable/3700093 (Accessed 14 May 2018).

Johnson, R.B., Onwuegbuzie, A.J., & Turner, L.A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, 1(2), pp. 112–133. https://doi.org/10.1177/1558689806298224

Jones, A. (2004). A review of the research literature on barriers to the uptake of ICT by teachers, Becta ICT Research, London. Available at: https://dera.ioe.ac.uk/1603/ (Accessed 20 August 2017).

Jones, L.L., & Hayes, A.E. (1980). How valid are surveys of teacher needs? *Educational Leadership*, 37(5), pp. 390-392.

Jorgensen, D.L. (1989). *Participant observation: A methodology for human studies*. Thousand Oaks, CA: Sage Publications.

Joyce, B.R., Mcnair, K.M., Diaz, R. & Mckibbin, M.D. (1976). *Interviews: perceptions of professionals and policy makers.* Stanford, CA: Stanford Centre for Research and Development in Teaching, Stanford University.

Kabakci Yurdakul, I., & Çoklar, A.N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning*, 30(4), pp. 363-376. https://doi.org/10.1111/jcal.12049

Kagan, D. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research*, Volume 62(2), pp.129–169. https://doi.org/10.3102/00346543062002129

Kannan, S., Sharma, S., & Abdullah, Z. (2012). Principal's strategies for leading ICT integration: The Malaysian perspective. Available at: https://doi.org/10.4236/ce.2012.38B023 (Accessed 24 November 2019).

Keengwe, J., & Kang, J. (2012). Blended learning in teacher preparation programs: A literature review. *International Journal of Information and Communication Technology Education* (IJICTE), 8(2), pp. 81-93.

https://doi.org/10.4018/jicte.2012040107

Kennedy, R. (2020). What's the Difference Between a Private School and an Independent School? Available at: https://www.thoughtco.com/private-school-versus-independent-school-2774234 (Accessed 21 April 2020).

Keys, P. (2007). A knowledge filter model for observing and facilitating change in teachers' beliefs. *Journal of Educational Change*, 8(1), pp. 41–60. https://doi.org/10.1007/s10833-006-9007-5

Khader, F.R. (2012). Teachers' pedagogical beliefs and actual classroom practices in social studies instruction. *American International Journal of Contemporary Research*, 2(1), pp. 73-92. Available at http://www.aijcrnet.com/journals/Vol_2_No_1_January_2012/9.pdf (Accessed 15 December 2017).

Khlaisang, J., & Likhitdamrongkiat, M. (2015). E-learning system in blended learning environment to enhance cognitive skills for learners in higher education. *Procedia-Social and Behavioral Sciences*, 174, pp. 759-767. https://doi.org/10.1016/j.sbspro.2015.01.612

Kim, H.J., & Jang H.Y. (2015). Factors Influencing Students 'Beliefs about the Future in the Context of Tablet-based Interactive Classrooms. *Computers and Education*, 89, pp. 1-15. http://dx.doi.org/10.1016/j.compedu.2015.08.014

Kimmons, R., Miller, B.G., Amador, J., Desjardins, C.D., & Hall, C. (2015). Technology integration coursework and finding meaning in pre-service teachers' reflective practice. *Educational Technology Research and Development*, 63(6), pp. 809–829. https://doi.org/10.1007/s11423-015-9394-5

Kinnaman, D.E. (1990). Staff development: How to build your winning team. *Technology & Learning*, 11(2), pp. 24-30.

Kirkland, K., & Sutch, D. (2009). Overcoming the barriers to educational innovation Literature reviews: Future lab. Available at https://www.nfer.ac.uk/publications/futl61/futl61.pdf (Accessed 20 November

2018).

Kler, S. (2014). ICT Integration in Teaching and Learning: Empowerment of Education with Technology. *Issues and ideals in education*, 2(2), pp. 255-271. https://doi.org/10.15415/iie.2014.22019

Knoblauch, D., & Hoy, A. (2008). "Maybe I can teach those kids": The influence of contextual factors on student teachers' efficacy beliefs. *Teaching and Teacher Education*, 24, pp. 166–179. http://dx.doi.org/10.1016/j.tate.2007.05.005

Koehler, M., Mishra, P., Kereluik, K., Shin, T., & Graham, C.R. (2014). The technological pedagogical content knowledge framework. In J.M. Spector, M.D. Merrill, J. Elen and M.J. Bishop (Eds.). *Handbook of research on educational communications and technology* (101–111). New York: Springer.

Koehler, M.J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, & technology. *Computers & Education*, 49(3), pp. 740-762.

Koh, J., & Chai, C. (2016). Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK). *Computers & Education*, 102, pp. 244–257.

Koh, J.H.J., Chai, C.S., and Tsai, C. (2014). Demographic Factors, TPACK Constructs, and Teachers' Perceptions of Constructivist-Oriented TPACK. *Journal of Educational Technology & Society*, 17(1), 185–96. Available at http://www.jstor.org/stable/jeductechsoci.17.1.185 (Accessed 13 May 2019).

Koh, J.H.L., Chai, C.S., and Tay, L.Y. (2014). TPACK-in-Action: Unpacking the contextual influences of teachers' construction of technological pedagogical content knowledge (TPACK). *Computers & Education*, 78, 20-29. https://doi.org/10.1016/j.compedu.2014.04.022

Koh, M. (2016 September 22). How to write effective research observations. Available at: https://uxmastery.com/how-to-write-effective-research-observations/ (Accessed 6 June 2018).

Korte, W.B., & Hüsing, T. (2007). Benchmarking access and use of ICT in European schools 2006: Results from Head Teacher and A Classroom Teacher Surveys in 27 European countries, eLearning Papers 2, 1: 1-6. Available at https://op.europa.eu/en/publication-detail/-/publication/74067431-ecd4-11e5-8a81-01aa75ed71a1 (Accessed 20 May 2018).

Kriek, J., & Stols, G. 2010. Teachers' beliefs and their intention to use interactive simulations in their classrooms. *SA Journal of Education,* 30(3), pp. 439-456. https://doi.org/10.15700/saje.v30n3a284

Krosnick, J.A., & Presser, S. (2010). Question and Questionnaire Design. In P.V. Marsden and J.D. Wright (Eds.). *Handbook of Survey Research*, 2nd ed. (263–313). Bradford, UK: Emerald Group Publishing Limited.

Kwela, M. R. (2013). An investigation of the effect of a short ICT Training Intervention on teachers' ability to integrate ICT into their teaching practice. Unpublished M.Ed., University of the Witwatersrand. Available at: http://wiredspace.wits.ac.za/bitstream/handle/10539/17800/Research%20Report_August%202013.pdf?sequence=3 (Accessed 4 October 2017).

Kyles, C., & Olafson, L. (2008). Uncovering preservice teachers' beliefs about diversity through reflective writing. *Urban Education*, 43, pp. 500–518. https://doi.org/10.1177/0042085907304963

La Paro, K., Siepak, K., & Scott-Little, C. (2009). Assessing beliefs of preservice early childhood education teachers using Q-sort methodology. *Journal of Early Childhood Teacher Education*, 30(1), pp. 22–36. https://doi.org/10.1080/10901020802667805

Langat, A.C. (2015). Barriers hindering implementation, innovation and adoption of ICT in primary schools in Kenya. *International journal of innovative research and development*, 4(2). Available at http://internationaljournalcorner.com/index.php/ijird_ojs/article/view/135215

(Accessed 15 April 2019).

Law, N. & Chow, A. (2008). Teacher characteristics, contextual factors, and how these affect the pedagogical use of ICT. In N. Law, W.J. Pelgrum & T. Plomp (Eds.), *Pedagogy and ICT Use in Schools around the World. Findings from the IEA SITES 2006 Study (CERC Studies in Comparative Education, 23,* (pp.181–219). Hong Kong: CERC-Springer. https://doi.org/10.1007/978-1-4020-8928-2_6

Law, N. (2008). Teacher learning beyond knowledge for pedagogical innovations with ICT. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 425–434). New York: Springer.

Law, N., Pelgrum, W.J. & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 Study. Comparative Education Research Centre*. Springer: The University of Hong Kong.

Lawless, K.A., & Pellegrino, J.W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, 77(4), pp. 575-614. https://doi.org/10.3102/0034654307309921

Lawrence, A.S.A., & Veena, K. (2012). Improving teacher competency through ICT. [Online]. Available at: http://www.academia.edu/1462066/ICT_AND_TEACHER_COMPETENCIES (Accessed 5 December 2018).

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, 40(3), pp. 191-204. https://doi.org/10.1016/S0378-7206(01)00143-4

Leithwood, K., & Mascall, B. (2008). Collective leadership effects on student achievement. *Educational Administration Quarterly*, 44(4), pp. 529-561.

https://doi.org/10.1177/0013161x08321221

Leithwood, K., Harris, A., & Hopkins, D. (2008). Seven strong claims about successful school leadership. *School Leadership & Management: Formerly School Organisation*, 28(1), pp. 27-42. Available at https://dera.ioe.ac.uk/6967/1/download%3Fid=17387&filename=seven-claims-about-successful-school-leadership.pdf (Accessed 3 November 2017).

Leuven, E., Lindahl, M., Oosterbeek, H., & Webbink, D. (2007). The effect of extra funding for disadvantaged pupils on achievement. *The Review of Economics and Statistics*, 89(4), pp. 721-736. https://doi.org/10.1162/rest.89.4.721

Levin, T. & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in the classroom: Developmental scenery. *Journal of Technology and Teacher Education*, 16(2), pp. 233–263. Available at https://www.learntechlib.org/primary/p/22950/ (Accessed 17 August 2018).

Levin, T., & Wadmany, R. (2006). Teachers' beliefs and practices in technology-based classrooms: A developmental view. *Journal of Research on Technology in Education*, 39(2), pp. 157–181. https://doi.org/10.1080/15391523.2006.10782478

Lewin, K. (1935). *A Dynamic Theory of Personality.* New York: McGraw Hil).

Li, Q. (2005). Infusing technology into a mathematics methods course: any impact? *Educational Research*, 47(2), pp. 217–233. https://doi.org/10.1080/00131880500104341

Li, Q. (2007). Student and teacher views about technology: a tale of two cities? *Journal of Research on Technology in Education*, Volume 39(4), pp. 377-397. Available at https://files.eric.ed.gov/fulltext/EJ768884.pdf (Accessed 23 May 2018).

Lim, C. P., & Chan, B. (2007). microLESSONS in teacher education: Examining pre-service teachers' pedagogical beliefs. *Computers & Education*, 48, pp. 474-494.

Lin, C.Y. (2008). Beliefs about using technology in the mathematics classroom: Interviews with pre-service elementary teachers. *Eurasia Journal of Mathematics, Science, & Technology Education*, 4(2), pp. 135-142. Available at https://files.eric.ed.gov/fulltext/ED502073.pdf (Accessed 1 July 2017).

Lincoln, Y.S. (1995). Emerging criteria for quality in qualitative and interpretive research. *Qualitative Inquiry*, 1(3), pp. 275–289. https://doi.org/10.1177/107780049500100301

Lincoln, Y.S., & Guba, E.G. (1985*). Naturalistic inquiry*. Beverly Hills, CA: Sage.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education*, 38(1), pp. 9-24, https://doi.org/10.1080/03054985.2011.577938

Lobiondo-Wood, G., & Haber, J (2013). *Nursing research in Canada. Methods, critical appraisal, and utilization,* 3rd ed. Toronto: Elsevier.

Lortie, D.C. (1975). *Schoolteacher: a sociological study*. Chicago, IL.: University of Chicago Press.

Lu, C., Huang, S., & Lo, P. (2010). An empirical study of on-line tax filing acceptance model: Integrating TAM and TPB. *African Journal of Business Management*, 4(5), pp. 800-810. Available at: https://academicjournals.org/journal/AJBM/article-abstract/A5408B323357 (Accessed 31 January 2018).

Lucking, R., Bligh, B., Munches, A., Ainsworth, S., Crook, C., & Noss, R. (2012). Decoding learning: The proof, promise and potential of digital education. Available at: https://media.nesta.org.uk/documents/decoding_learning_report.pdf (Accessed 31 March 2018)

Lugano, G. (2002). Finnish and Italian technology in the global environment of European community: A comparison of ICT strategies in education. Unpublished thesis, University of Bologna. Available at http://www.edscuola.it/archivio/software/itc_fi_it_en.pdf (Accessed 17 April 207).

Lui, S.H. (2011). Factors related to pedagogical beliefs of teachers and technology integration. *Computers & Education*, 56(4), pp. 1012-1022. https://doi.org/10.1016/j.compedu.2010.12.001

Luszczynska, A., & Schwarzer, R. (2005). Social cognitive theory. In M. Conner & P. Norman (Eds.), *Predicting health behaviour: research and practice with social cognition models*, 2nd ed. (pp. 127–169). Buckingham, England: Open University Press.

Machin, S., McNally, S., & Silva, O. (2007). New technology in Schools: Is there a payoff? *Economic Journal*, 117(522), pp. 1145-167. http://dx.doi.org/10.1111/j.1468-0297.2007.02070

Magos, K. (2006). Teachers from the majority population — Pupils from the minority: Results of a research in the field of Greek minority education. *European Journal of Teacher Education*, 29, pp. 357–369. https://doi.org/10.1080/02619760600795189

Makgato, M. (2012). Status of teachers' use of educational technology: A case of some schools in South African Semi-Urban Locations. International Proceedings of Economics Development and Research (IPEDR), 47(23), pp 107-110. Available at: http://www.ipedr.com/vol47/023-ICERI2012-S10014.pdf (Accessed 15 August 2017).

Mama, M., & Hennessy, S. (2013). Developing a typology of teacher beliefs and practices concerning classroom use of ICT. *Computers & Education*, 68, pp. 380-387. https://doi.org/10.1016/j.compedu.2013.05.022

Marangunić, N., & Granić, A. (2014). Technology acceptance model: a literature review from 1986 to 2013. 14, pp. 81–95. https://doi.org/10.1007/s10209-014-0348-1

Markauskaite, L. (2007). Exploring the structure of trainee teacher's ICT literacy: The main components of and relationships between, general cognitive and technical capabilities. *Educational Technology, Research and Development*, 55(6), pp. 547–572. Available at https://www.jstor.org/stable/30221252 (Accessed 19 November 2018).

Martin, S.F., Shaw, E.J., & Daughenbaugh, L. (2014). Using Smart Boards and manipulatives in the elementary science classroom. *Techtrends*: *Linking Research and Practice to Improve Learning*, , 58(3), pp. 90-96. https://doi.org/10.1007/s11528-014-0756-3

Martinovic, D., & Zhang, Z. (2012). Situating ICT in the teacher education program: Overcoming challenges, fulfilling expectations. *Teaching and Teacher Education*, 28(3), pp. 461-469. https://doi.org/10.1016/j.tate.2011.12.001

Mathieson, K. (1991). Predicting user intentions: comparing the technology acceptance model with the theory of planned behaviour. *Information systems research*, 2(3), pp. 73-191. https://doi.org/10.1287/isre.2.3.173

Mathipa, E. R., & Mukhari, S. (2014). Teacher Factors Influencing the Use of ICT in Teaching and Learning in South African Urban Schools. *Mediterranean Journal of Social Sciences,* 5(23), pp. 1213–1220. https://doi.org/10.5901/mjss.2014.v5n23p1213

Matzen, N., & Edmunds, J. (2007). Technology as a catalyst for change: The role of professional development. *Journal of Research on Technology in Education*, 39(4), pp. 417–430. https://doi.org/10.1080/15391523.2007.10782490

Maxcy, S. (2003) Pragmatic threads in mixed methods research in the social sciences. The search for multiple modes of inquiry and the end of the philosophy of formalism. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of Mixed Methods in Social and Behavioural Research.* Thousand Oaks, CA: Sage.

Maxwell, J.A. (1996). *Qualitative research design: An interactive approach*. London: Sage.

Mayer, R. E. (2009). *Multimedia learning,* 2nd ed. Santa Barbara, CA: Oxford

University Press.

Mayer, R.E. (2003). Theories of learning and their application to technology. In H.F. O'Neil Jr. & R.S. Perez (Eds.), *Technology applications in education: A learning view* (pp. 127–157). Mahwah, NJ: Erlbaum.

Mbatha, K. (2015). Teachers' ICT integration challenges: A case study in Orlando East, South Africa. Unpublished M.Ed., University of the Witwatersrand. Available at: http://wiredspace.wits.ac.za/jspui/bitstream/10539/18226/2/Final%20Report%20Research%202015.pdf (Accessed 12 August 2017).

Mdlongwa, T. (2012). Information and Communication technology (ICT) as a means of enhancing Education in Schools in South Africa: Challenges, Benefits and Recommendations. Africa Institute of South Africa. Policy Brief 80. Available at: Available at http://www.ai.org.za/wp-content/uploads/downloads/2012/10/No.-80.-ICTas-a-means-of-enhancing-Education-in-Schools-in-South-Africa.pdf (Accessed 25 June 2017).

Miheso, J.M., & Mavhunga, E. (2020). The retention of topic specific pdc: a longitudinal study with beginning chemistry teachers. *Chemistry Education Research and Practice,* 21, pp. 789-805. https://doi.org/10.1039/d0rp00008f

Miller, L., Naidoo, M., Van Belle, J.P. & Chigona, W. (2006). School-level ICT Adoption Factors in the Western Cape Schools. Proceedings of IEEE 4th International Workshop on Technology for Education in Developing Countries, Iringa, Tanzania, pp. 57-61. https://doi.org/10.1109/TEDC.2006.24

Mills, S., & Tincher, R. (2003). Be the technology: a developmental model for evaluating technology integration. *Journal of Research on Technology in Education,* 35(3), pp. 382–401. https://doi.org/10.1080/15391523.2003.10782392

Minichielle, V., Aroni, R., & Hays, T. (2008). *In Depth Interviewing: Principles, Techniques, Analysis*. Pearson: Sydney.

Mishra, P., & Koehler, M.J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record,* 108(6), pp. 1017-1054. Available https://www.tcrecord.org/content.asp?contentid=12516 (Accessed 23 May 2019).

Mishra, P., & Koehler, M.J. (2009). What Is Technological Pedagogical Content Knowledge? Available at: http://www.citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogicalcontent-knowledge (Accessed 25 May 2018).

Modell, S. (2009). In defence of triangulation: a critical realist approach to mixed methods research in management accounting. *Management Accounting Research*, 20(3), pp. 208-221. https://doi.org/10.1016/j.mar.2009.04.001

Mofokeng, L.S., & Mji, A. (2010). Teaching Mathematics and Science using computers: How prepared are South African teachers to do this? *Procedia - Social and Behavioural Sciences*, 2(2), pp. 1610-1614. https://doi.org/10.1016/j.sbspro.2010.03.245

Mohanasundaram, K. (2018). Curriculum Design and Development. *Journal of Applied and Advanced Research*, 3(Suppl. 1), pp. S4–S6. https://doi.org/https://doi.org/10.21839/jaar.2018.v3iS1.156

Montaño, D.E., & Kasprzyk, D. (2015). Theory of reasoned action, theory of planned behavior, and the integrated behavioral model. In K. Glanz, B. K. Rimer, & K.V. Viswanath (Eds.), *Health behavior: Theory, research, and practice* (pp. 95–124). California: Jossey-Bass/Wiley.

Moore-Hayes, C. (2011). Technology integration preparedness and its influence on teacher-efficacy. *Canadian Journal of Learning and Technology*, 37(3), pp. 1-15. https://doi.org/10.21432/T2B597

Morgan, D.L. (2007) Paradigms lost and pragmatism regained: methodological implications of combining qualitative and quantitative methods. *Journal of Mixed*

Methods Research, 1(1), pp. 48-76. https://doi.org/10.1177/2345678906292462

Msila, V. (2015). Teacher Readiness and Information and Communications Technology (ICT) Use in Classrooms: A South African Case Study. Creative Education, 6(18). https://doi.org/10.4236/ce.2015.618202

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers and Education*, 51(4), pp. 1523–1537. https://doi.org/10.1016/j.compedu.2008.02.003

Mukhari, S.S (2016). Teachers' experience of information and communication technology for teaching and learning in urban schools. Unpublished PhD Thesis, University of South Africa.

Mungai, M. (2011). Challenges facing computer education in Kenya schools. Available at: https://www.ictworks.org/12-challenges-facing-computer-education-kenyan-schools/#.YL7tCvkzaUk (Accessed 15 November 2018).

Mwalongo, A. (2011). Teachers' perceptions about ICT for teaching, professional development, administration and personal use. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 7(3), pp. 36-49. Available at http://ijedict.dec.uwi.edu/include/getdoc.php?id=4888&article=1272&mode=pdf (Accessed 23 June 2019).

Mweli, H. M. (2013). Status Report on the Implementation of e-Education. Available at: https://slideplayer.com/slide/5835661/ (Accessed 13 December 2019).

Naicker, V. (2010). Educator's pedagogy influencing the effective use of computers for teaching purposes in classrooms: Lessons learned from secondary schools in South Africa. *Educational Research and Review*, 5(11), pp. 679-689. Available https://core.ac.uk/reader/62636270 (Accessed 23 August 2017).

National Planning Commission. (2017). National Development Plan. Vision for 2030.

Pretoria: Government Printers.

National Research Council. (1999). *Being fluent with information technology literacy. Computer science and telecommunications board commission on physical sciences, mathematics, and applications.* Washington, DC.: National Academy Press

National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC.: National Academy Press.

Nazarenko, A.L. (2014). Information technologies in education: Blended learning (an attempt of a research approach). *Procedia - Social and Behavioural Sciences*, 154, pp. 53-56. https://doi.org/10.1016/j.sbspro.2014.10.111

NDET. (2008). Knowledge promotion. [Online]. http://dx.doi.org/10.18261/ISSN1891-943X-2013-01-02-07

Ndlovu, S., & Lawrence, D. (2012). The quality of ICT use in South African classrooms. A paper presented at "Towards Carnegie111, held at the University of Cape Town from 3-7 September 2012. [Online]. Available at: http://www.carnegie3.org.za/docs/papers/197_Ndlovu_The%20quality%20of%20ICT%20use%20in%20South%20African%20classrooms.pdf (Accessed 6 May 2018).

Ngwu, O.G. (2014). Assessment of availability and utilization of ICT resources in teaching in F.C.E Eha-Amufu Enugu Nigeria. ICELW 2014. Available at http://learningideasconf.s3.amazonaws.com/Docs/Past/2014/papers/Ngwu.pdf (Accessed 23 June 2018).

Nigam, A. (2013). Sampling: Why and How of it? *Indian journal of medical specialities*, 4(2), pp. 330-333. https://doi.org/10.7713/ijms.2013.0032

Nistor, N., & Heymann, J.O. (2010). Reconsidering the role of attitude in the TAM: An answer to Teo (2009a). *British Journal of Educational Technology*, 41(6), pp. 142–145. https://doi.org/10.1111/j.1467-8535.2010.01109.x

Nistor, N., Schworm, S., & Werner, M. (2012). Online help-seeking in communities of practice: Modeling the acceptance of conceptual artefacts. *Computers & Education*, 59(2), pp. 774–784. https://doi.org/10.1016/j.compedu.2012.03.017

Nkula, K. & Krauss, K.E. (2014). The integration of ICTs in marginalized schools in South Africa: Considerations for understanding the perceptions of in-service teachers and the role of training. Available at https://canvas.harvard.edu/courses/18484/files/3207854/download?verifier=EpBWXgXd7FGht5Fl0Yq9u1rhiClVNsTIK71ITxeR&wrap=1 (Accessed 24 June 2018).

Nosek, B.A., Graham, J., Lindner, N.M., Kesebir, S., Hawkins, C.B., Hahn, C., Tenney, E.R. (2010). Cumulative and career-stage citation impact of social-personality psychology programs and their members. *Personality and Social Psychology Bulletin*, 36, pp. 1283–1300. https://doi.org/10.1177/0146167210378111

OFSTED (2001). ICT in schools: The impact of government initiatives – An interim report April 2001. Available at https://dera.ioe.ac.uk//4719/ (Accessed 7 June 2018).

OFSTED (2002). ICT in schools: Effect of government initiatives: Pupils' achievement. Available https://core.ac.uk/download/pdf/4159516.pdf (Accessed 8 June 2018).

Okojie, M., Olinzock, A., & Okojie-Boulder, T. (2006). The pedagogy of technology integration. *The Journal of Technology Studies*, 32, pp. 66–71. https://doi.org/10.21061/jots.v32i2.a.1

Olson, K., & Jimenez-Silva, M. (2008). The campfire effect: A preliminary analysis of preservice teachers' beliefs about teaching English language learners after state mandated endorsement courses. *Journal of Research in Childhood Education*, 22, pp. 246–260. https://doi.org/10.1080/02568540809594625

Onwuegbuzie, A.J., & Johnson, R.B. (2006). The validity issue in mixed research.

Research in the Schools, 13(1), pp. 48-63. Available http://www.msera.org/docs/rits-v13n1-complete.pdf (Accessed 23 May 2018).

Orlando, J. (2009). Understanding changes in teachers' ICT practices: A longitudinal perspective. *Technology, Pedagogy and Education*, 18(1), pp. 33-44. https://doi.org/10.1080/14759390802704030

Ormrod, J.E. (2006). *Educational psychology: Developing learners*, 5th ed. Upper Saddle River, N.J.: Pearson/Merrill Prentice Hall.

Ottenbreit-Leftwich, A.T. (2007). Expert technology-using teachers: Visions, strategies, and development. Unpublished Ph.D. Purdue University, West Lafayette. Available at https://www.learntechlib.org/p/119871/ (Accessed 23 November 2017).

Ottestad, G. (2013). School Leadership for ICT and Teachers' Use of Digital Tools. *Nordic Journal of Digital Literacy,* 8(7), pp. 107–125. Available at: https://www.idunn.no/dk/2013/01-02/school_leadership_for_ict_and_teachers_use_of_digital_tools (Accessed 27 September 2017).

Padayachee, K. (2017) A Snapshot Survey of ICT Integration in South African Schools. *South African Computer Journal*, 29, pp. 2, 36-65.

Padgett, D.K. 2008. *Qualitative methods in social work research*. Thousand Oaks, California: Sage.

Park, N. (2010). Adoption and use of computer-based voice over internet protocol phone service: Toward an integrated model. *Journal of communication*, 60(1), pp. 40–72. https://doi.org/10.1111/j.1460-2466.2009.01440.x

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods*, 3rd ed. Los Angeles: Sage.

Paul, K.J., Musa, M., & Nansubuga, A.K. (2015). Facilitating Condition for E-learning Adoption — Case of Ugandan Universities. *Journal of Communication and*

Computer, 12, pp. 244-249. https://doi.org/10.17265/1548-7709/2015.05.004

Pedersen, S., & Liu, M. (2003). Teachers' beliefs about issues in the implementation of a student-centred learning environment. *Educational Technology Research and Development*, 51(2), pp. 57–76. https://doi.org/10.1016/j.sbspro.2013.08.805

Peeraer, J., & Van Petegem, P. (2011). How to address integration of ICT in teaching practice? Research on factors influencing the use of ICT in education. Available at: https://www.researchgate.net/publication/258312739_How_to_address_Integration_of_ICT_in_Teaching_Practice_Research_on_Factors_influencing_the_use_of_ICT_in_Education (Accessed 6 January 2020).

Pelgrum, W.J., & Voogt, J. (2009). School and teacher factors associated with frequency of ICT use by mathematics teachers: Country comparisons. *Educ Inf Technol*, 14, 293. https://doi.org/10.1007/s10639-009-9093-0

Petko, D. (2012). Teachers' pedagogical beliefs and their use of digital media in classrooms: Sharpening the focus of the 'will, skill, tool' model and integrating teachers' constructivist orientations. *Computers & Education*, 58(4), pp. 1351-1359. https://doi.org/10.1016/j.compedu.2011.12.013

Pfundt, H., & Duit, R. (2000). *Bibliography: Student's alternative frameworks and science education,* 5th ed. Kiel, Germany: University of Kiel.

Pinar, W. F. (2010). Currere. In C. Kridel (Ed.), *Encyclopedia of curriculum studies*. London: Sage.

Plano-Clark, V., & Ivankova, N. V. (2017). What is Mixed Methods Research? Considering How Mixed Methods Research is defined. In *Mixed Methods Research: A Guide to the Field* (55-78). SAGE Publications, Inc. Available at: https://www-doi-org.ufs.idm.oclc.org/10.4135/9781483398341 (Accessed 7 May 2018).

Error! Hyperlink reference not valid. Plowright, D. (2011). *Using Mixed Methods:*

Frameworks for an Integrated Methodology, Washington DC.: Sage Publications.

Polit, D.F., & Beck, C.T. (2006). *Essentials of Nursing Research: Methods, Appraisal, and Utilization*, 6th ed. Philadelphia PA.: Lippincott Williams and Wilkins.

Polit, D.F., & Beck, C.T. (2012) Nursing Research: Generating and Assessing Evidence for Nursing Practice. 9th Edition, Lippincott, Williams & Wilkins, Philadelphia.

Polkinghorne, D.E. (2005). Language and meaning: data collection in qualitative research. *Journal of Counselling Psychology*, 52, pp. 137-145. http://dx.doi.org/10.1037/0022-0167.52.2.137

Portnoy, L. (2018). How SAMR and Tech Can Help Teachers Truly Transform Assessment. Available at https://www.edsurge.com/news/2018-02-01-how-samr-and-tech-can-help-teachers-truly-transform-assessment (Accessed 24 May 2018).

Pozo-Rico, T., Gilar-Corbi, R., Izquierdo, A. & Castejoin, J. (2020). Teacher Training Can Make a Difference: Tools to Overcome the Impact of COVID-19 on Primary Schools. An Experimental Study. *Int. J. Environ. Res. Public Health*, 17*(22).* Available at: https://doi.org/10.3390/ijerph17228633 (Accessed 19 February 2022).

Prestridge, S. (2010). ICT professional development for teachers in online forums: Analysing the role of discussion. *Teaching and Teacher Education*, 26(2), pp. 252-258. https://doi.org/10.1016/j.tate.2009.04.004

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education*, 58(1), pp. 449–458. https://doi.org/10.1016/j.compedu.2011.08.028

Puentedura, R. (2006). Transformation, technology, and education [Blog post].

Available at: http://hippasus.com/resources/tte/puentedura_tte.pdf (Accessed 25 May 2018).

Puentedura, R. (2014). Building transformation: An introduction to the SAMR model. Available at: http://www.hippasus.com/rrpweblog/archives/2014/08/22/BuildingTransformation_AnIntroductionToSAMR.pdf (Accessed 25 May 2018).

Putnam, R.T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, 29(1), pp. 4–15. https://doi.org/10.3102/0013189X029001004

Pynoo, B., & Van Braak, J. (2014). Predicting teachers' generative and receptive use of an educational portal by intention, attitude and self-reported use. *Computers in Human Behavior*, 34, pp. 315–322. https://doi.org/10.1016/j.chb.2013.12.024

Pynoo, B., Devolder, P., Duyck, W., Van Braak, J., Sijnave, B., & Duyck, P. (2012). Do hospital physicians' attitudes change during PACS implementation? A cross-sectional acceptance study. *International Journal of Medical Informatics*, 81(2), pp. 88–97. https://doi.org/10.1016/j.ijmedinf.2011.10.007

Pynoo, B., Devolder, P., Tondeur, J., Van Braak, J., Duyck, W., & Duyck, P. (2011). Predicting secondary school teachers' acceptance and use of a digital learning environment: A cross-sectional study. *Computers in Human Behaviour*, 27(1), pp. 568–575. https://doi.org/10.1016/j.chb.2010.10.005

Pynoo, B., Devolder, P., Voet, T., Sijnave, B., Gemmel, P., Duyck, W., Van Braak, J., & Duyck, P. (2013). Assessing hospital physicians' acceptance of clinical information systems: A review of the relevant literature. *Psychologica Belgica*, 53(2), pp. 15–31. https://doi.org/10.5334/pb-53-2-15

Qasem, A.A.A., & Viswanathappa, G. (2016). Teacher perceptions towards ICT integration: Professional development through blended learning. *Journal of Information Technology Education: Research*, 15, pp. 561-575. https://doi.org/10.28945/3562

QSR International. (2012). NVivo 12 Qualitative data analysis software package. Doncaster, Victoria, Australia: QSR International.

Qu, S.Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting & Management*, 8(3), pp. 238-264. https://doi.org/10.1108/11766091111162070

Rahimi, S.R., Beer, C.D., & Sewchuran, K. (2012). The Conceptual Difficulties in Implementing e-Learning in Post-Apartheid South Africa. International Journal of Information and Education Technology, 2(6), pp. 615-621, https://doi.org/10.7763/IJIET.2012.V2.217

Ratminingsih, N.M., Mahadewi., L. P.P., & Divayana, D.G.H (2018). ICT-Based Interactive Game in TEYL: Teachers' Perception, Students' Motivation, and Achievement. *International Journal of Emerging Technologies in Learning*, 13(9), pp. 190-203.

Ramorola, M.Z. (2014). Challenge of effective technology integration into teaching and learning. *Africa Education Review*, 10(4): pp. 654 – 670, https://doi.org/10.1080/18146627.2013.853559 .

Reed Y, Gultig J., & Adendorff, M. (2012). *Curriculum: organizing knowledge for the classroom*, 3rd ed. Cape Town: Oxford University Press.

Reynolds, D. (2001). ICT in education: The future research and policy agenda. In Proceedings of the Building an ICT Research Network Conference. Available at: http://www.becta.org.uk/research/reports/ (Accessed 24 February 2017).

Rieber, L.P., & Welliver, P.W (1989). Infusing educational technology into mainstream educational computing. *International Journal of Instructional Media*, 16(1), pp. 21-32.

Rimm-Kaufman, S., Storm, M., Sawyer, B., Pianta, R., & LaParo, K. (2006). The Teacher Belief Q-Sort: A measure of teachers' priorities in relation to disciplinary practices, teaching practices, and beliefs about children. *Journal of School Psychology*, 44(2), pp. 141–165.

https://doi.org/10.1016/j.jsp.2006.01.003

Roberts, N., Mmekoa, M., & Mawoyo, M. (2009). Intel® Teach 2008 Evaluation Report: A Focus on the Western Cape Education Department Intel® Teach Essentials Model. Available at https://www.schoolnet.org.za/research/0905_intel_evaluation.pdf (Accessed 11 April 2018).

Robinson, V., Hohepa, M., & Lloyd, C. (2009). School Leadership and Student Outcomes: Identifying What Works and Why Best Evidence Synthesis. Available at https://www.educationcounts.govt.nz/publications/series/2515/60170 (Accessed 12 April 2018).

Rogers, E.M. (1995). *Diffusion of Innovations,* 4th ed. New York: The Free Press.

Roos, G. (2002). Teaching with ICT Framework, Sheikh Mohammed IT Education Project, Dubai.

Rorty, R. (1999). *Philosophy and Social Hope*. London: Penguin.

Roth, K. (2014). Technology for tomorrow's teachers. *Journal of Physical Education, Recreation & Dance*, 85(4), pp. 3-5. https://doi.org/10.1080/07303084.2014.884420 .

Rudduck, J. (1986). Making the most of the short inservice course. In D. Hopkins (Ed.). *Inservice Training and Educational Development: An International Survey* (302-311). Beckenham: Croom Helm.

Ruthven, K., Hennessy, S., & Deaney, R. (2003). Incorporating Internet resources into classroom practice: pedagogical perspectives and strategies of secondary-school subject teachers. *Computers and Education,* 44(1), pp. 1-34. https://doi.org/10.1016/j.compedu.2003.11.001

Sabzian, F., & Gilakjani, A.P. (2013). Teachers' attitudes about computer technology training, professional development, integration, experience, anxiety, and literacy in English language teaching and learning. *International Journal of Applied*, 3(1), pp. 18-26. Available at http://ijastnet.com/journals/Vol_3_No_1_January_2013/9.pdf (Accessed 23 May 2019).

Sanchez-Garcia, A., Marco, J.M., Gualin, H. & Escribano, J. P. (2013). Teacher Development and ICT: The Effectiveness of a Training Program for In-Service School Teachers. *Procedia - Social and Behavioural Sciences*, Volume 92, pp. 529 – 534.

Sandholtz, J., & Reilly, B. (2004). Teachers, Not Technicians: Rethinking Technical Expectations for Teachers. [Online]. Available at: http://www.tcrecord.org/Content.asp?ContentId=11525 **Error! Hyperlink reference not valid.**(Accessed 20 August 2017).

Sang, G., Valcke, M., Van Braak, K., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviours with educational technology. *Computers & Education*, 54(1), pp. 103-112. https://doi.org/10.1016/j.compedu.2009.07.010

Satake, E. (2015). Statistical Methods and reasoning for the clinical sciences: Evidence based practice. Plural Publishing

Saunders, M., Lewis, P. and Thornhill, A. (2007) Research Methods for Business Students. 4th ed. Harlow, England: Pearson Education Limited.

Sauro, J. (2015). 4 Types of Observational Research. Available at: https://measuringu.com/observation-role/ (Accessed 28 May 2018).

Schensul, S.L., Schensul, J.J., and LeCompte, M.D. (1999). *Essential ethnographic methods: observations, interviews, and questionnaires.* Walnut Creek, CA: AltaMira Press.

Scherer, R., Siddiq, F., & Teo, T. (2015). Becoming more specific: Measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Computers & Education*, 88, pp. 202-214.

http://dx.doi.org/10.1016/j.compedu.2015.05.005

Scherer, R., Siddiq, F., & Tondeur, J. (2018). The technology acceptance model (TAM): A meta-analytic structural equation modelling approach to explaining teachers' adoption of digital technology in education. *Computers & Education,* 128, pp. 13-35. https://doi.org/10.1016/j.compedu.2018.09.009

Scherer, R., Tondeur, J., & Baran, E. (2018). The importance of attitudes towards technology for pre-service teachers' technological pedagogical, and content knowledge: Comparing structural equation model approaches. *Computers in Human Behaviour,* 80, pp. 67-80.

Schneider, R.M., & Plasman, K. (2011). Science teacher learning progressions: A review of science teachers' pedagogical content knowledge development. *Review of Educational Research*, 81(4), pp. 530–565. https://doi.org/10.3102/0034654311423382

Schofield, J.W. (1993). Increasing the generalizability of qualitative research. In M. Hammersley (Ed.), *Educational research: Current issues* (pp. 91-113). London: Paul Chapman Publishing.

Schweisfurth, M. (2013). *Learner-centred education in international perspective: Whose pedagogy for whose development?* London: Routledge.

Scott, P.J., & Briggs, J.S. (2009). A pragmatist argument for mixed methodology in medical informatics. *Journal of Mixed Methods Research*, 3(3), pp. 223-241. https://doi.org/10.1177/1558689809334209

Scrimshaw, P. (2004). Enabling teachers to make successful use of ICT. Available at: https://dera.ioe.ac.uk//1604/ (Accessed 20 August 2017).

Shan Fu, J. (2013). Complexity of ICT in Education: A critical Literature review and its implications. *International Journal of Education and Development using ICT* (IJEDICT), 9(1), pp. 112-125. Available at https://www.learntechlib.org/p/111900/ (Accessed 17 August 2019).

Shapka, J.D., & Ferrari, M. (2003). Computer-related attitudes and actions of teacher candidates. *Computers in Human Behaviour*, 19(3), pp. 319–334. https://doi.org/10.1016/S0747-5632(02)00059-6

Shelton, M. & Jones, M. (1996). Staff development that works! A tale of four T's. *NASSP Bulletin*, 80(582), pp. 99-105. Available at https://www.learntechlib.org/p/82533/ (Accessed 23 September 2017).

Shenton, A.K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2), pp. 63–75. Available at https://www.pm.lth.se/fileadmin/_migrated/content_uploads/Shenton_Trustworthiness.pdf (Accessed 17 November 2017).

Shepherd, C., Bolliger, D., Dousay, T., & Persichitte, K. (2016). Preparing teachers for online instruction witha graduate certificate program. *TechTrends*, 60(1), pp. 41–47.

Sherman, K., & Howard, S.K. (2012). Teachers' beliefs about first and second-order barriers to ICT integration: preliminary findings from a South African study. Paper presented at the 23rd International Conference of Society for Information Technology and Teacher Education. Charlottesville, VA: Association for the Advancement of Computing in Education. Available https://ro.uow.edu.au/edupapers/1207/ (Accessed 13 May 2019).

Sherry, L., Billig, S., Tavalin, F., & Gibson, D. (2002). An Integrated Technology Adoption and Diffusion Model. Available at: Available at https://files.eric.ed.gov/fulltext/ED444565.pdf (Accessed 20 November 2017).

Shiboko, L.C. (2015). Teacher factors influencing integration of Information communication technology in teaching of English in public secondary schools in Mumias sub-county, Kenya. Unpublished M.Ed. thesis, University of Nairobi. Available at http://erepository.uonbi.ac.ke/handle/11295/90128 (Accessed 10 December 2019).

Shriner, M., Schlee, B., Hamil, M. & Libler, R. (2009). Creating teachers' perceptual, behavioral, and attitudinal change using professional development workshops. *Teacher Development*, 13(2), pp. 125-134. https://doi.org/10.1080/13664530903043947

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher,* 15(2), pp. 4-14. https://doi.org/10.3102/0013189X015002004

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), pp. 1- 22. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Singleton, R.A., & Straits, B.C. (2009). *Approaches to social research.* New York: Oxford University Press.

Sipilä, K. 2014. Educational use of information and communication technology: Teachers' perspective. *Technology, Pedagogy and Education*, 23(2), pp. 225-241. https://doi.org/10.4018/IJICTE.2017070104

Siragusa, L., & Dixon, K. (2009). Theory of planned behaviour: Higher education students' attitudes towards ICT-based learning interactions. Available at https://www.ascilite.org/conferences/auckland09/procs/siragusa.pdf (Accessed 17 August 2019).

Skryabin, M., Zhang, J., Liu, L., & Zhang, D. (2015). How the ICT development level and usage influence student achievement in reading, mathematics, and science. *Computers & Education,* 85, pp. 49-58. http://dx.doi.org/10.1016/j.compedu.2015.02.004

Slack, F. (2001). Observation: Perspectives on Research Methodologies for Leisure Managers. *Management Research News*, 24(1), pp. 35–42. https://doi.org/10.1108/01409170010781984

Smarkola, C. (2008). Efficacy of a planned behaviour model: Beliefs that contribute to computer usage intentions of student teachers and experienced teachers. *Computers in Human Behaviour,* 24(30), pp. 1196-1215. https://doi.org/10.1016/j.chb.2007.04.005

Smith, C. (2019). 4IR is a path to prosperity for Africa. Available at: https://www.iol.co.za/business-report/opinion/opinion-4ir-is-a-path-to-prosperity-for-africa-29746475 (Accessed 4 August 2020).

Smith, S., & Robinson, S. (2003). Technology integration through collaborative cohorts. Preparing future teachers to use technology. *Remedial and Special Education*, 24, pp.154 –160. https://doi.org/10.1177/07419325030240030401

Snoeyink, R., & Ertmer, P.A. (2002). Thrust into technology: How veteran teachers respond. *Journal of Educational Technology Systems*, 30(1), pp. 85–111. Available at https://journals.sagepub.com/doi/pdf/10.2190/YDL7-XH09-RLJ6-MTP1 (Accessed 17 June 2017).

Somekh, B. (2008). Factors affecting teachers' pedagogical adoption of ICT. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp.449–460). New York: Springer.

South African Institute for Distance Education (SAIDE). (2005). Managing ICTs in South African schools: A guide for school principals. Available at https://www.eldis.org/document/A20686 (Accessed 11 September 2017).

Spaull, N. (2013). Poverty & privilege: Primary school inequality in South Africa. *International Journal of Educational Development,* 33(5), pp. 436-447. https://doi.org/10.1016/j.ijedudev.2012.09.009

Spector, J.M. (2010). An overview of progress and problems in educational technology. *Interactive Educational Multimedia*, Volume 3, pp. 27–37. Available at https://revistes.ub.edu/index.php/IEM/article/view/11731 (Accessed 23 October 2018).

Spillane, J. P. (2005). Distributed Leadership. *The Educational Forum*, 69(2), pp. 143-150. https://doi.org/10.1080/00131720508984678

Starkey, L. (2011). Evaluating learning in the 21st century: a digital age learning matrix. Available at http://www.tandfoline.com/loi/rtpe20. (Accessed 20 September 2020).

Steyn, J., & Van Greunen, D. (Eds). (2014). *ICTs for inclusive communities in developing societies.* Newcastle upon Tyne: Cambridge Scholars Publishing.

Stoll, L. (1999). Realising our potential: Understanding and developing capacity for lasting improvement. *School effectiveness and school improvement*, 10(4), pp. 503–532. Available at https://www.tandfonline.com/doi/abs/10.1076/sesi.10.4.503.3494 (Accessed 12 November 2017).

Stols, G. (2008). Why don't teachers use ICT in their classrooms? Paper presented at the 16th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education, Maseru, Lesotho.

Stott, A. E. (2018a). Physical sciences teachers' beliefs about Technology for teaching and factors influencing their uptake of a specific technology, paper presented to the SAARMSTE conference, Botswana, 16 – 19 January 2018.

Stott, A.E. (2018). Are instructivist pedagogies more appropriate for learning the sciences in South African low-quintile schools than western literature suggests? *Journal of Education,* 71, pp. 39-57. http://dx.doi.org/10.17159/2520-9868/i71a03

Stott, A.E. (2020a). Beliefs of learners and teachers in contexts of poverty regarding curriculum-aligned science electronic quiz engagement. Proceedings of the Australian Conference on Science and Mathematics Education, Virtual. Available at https://openjournals.library.sydney.edu.au/index.php/IISME/article/view/14636 (Accessed 12 September 2021).

Stott, A.E. (2020b). Extracurricular Electronic Science Quiz Engagement in Poverty. Global Information Technology Management Association World Conference, Virtual conference.

Stott, A.E., & Beelders, T. (2019). The influence of science reading comprehension on South African township learners' learning of science. *South African Journal of Science,* 115(1-2), pp. 72-80. https://doi.org/10.17159/sajs.2019/5146

Stott, A.E., & Case, J.M. (2014). Electronic tutoring as a tool for promoting conceptual change: A case study of in-service science teacher workshops. *African Journal of Research in Mathematics, Science and Technology Education*, 18(2), pp. 139-150. https://doi.org/10.1080/10288457.2014.912832

Streubert, H.J. (2007). Designing data generation and management strategies. In H.J. Streubert and D.R. Carpenter (Eds.), *Qualitative research in nursing: advancing the humanistic imperative,* 3rd ed. (pp. 33-56). Philadelphia, Pennsylvania, USA: Lippincott Williams & Wilkins.

Stuart, L.H., Mills, A.M., & Remus, U. (2009). School leaders, ICT competence and championing innovations. *Computers & Education*, 53(3), pp. 733-741. https://doi.org/10.1016/j.compedu.2009.04.013

Sugar, W., Crawley, F., & Fine, B. (2004). Examining teachers' decisions to adopt new technology. *Educational Technology and Society*, 7(4), pp. 201-213. Available at https://www.jstor.org/stable/jeductechsoci.7.4.201 (Accessed 23 October 2017).

Surbi, S. (2016). Difference between Probability and Non-Probability Sampling [Blog Post]. Available at: https://keydifferences.com/difference-between-probability-and-non-probability-sampling.html (Accessed 24 May 2018).

Surbi, S. (2017). Difference between Validity and Reliability [Blog Post]. Available at: https://keydifferences.com/difference-between-validity-and-reliability.html

(Accessed 14 June 2018).

Sure, S. (2009). Development of a tool to measure computer self-efficacy of student teachers. Available at: http://www.academia.edu/1338238/development_of_a_tool_to_measure_computer_self-efficacy_of_student_teachers (Accessed 4 October 2017).

Synder, H (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research,* , 104, pp. 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Tabulawa, R., (2013). Teaching and learning in context: Why pedagogical reforms fail in Sub-Saharan Africa. Council for the Development of Social Science Research in Africa.

Tallvid, M. (2016). Understanding teachers' reluctance to the pedagogical use of ICT in the 1:1 classroom. *Education and Information Technologies*, 21(3), pp. 503–519.

Tashakkori, A., & Creswell, J.W. (2007). The new era of mixed methods. *Journal of Mixed Methods Research*, 1(1), pp. 3–7. https://doi.org/10.1177/2345678906293042

Tashakkori, A., & Teddlie, C. (1998). *Mixed Methodology: Combining the Qualitative and Quantitative Approaches*. Thousand Oaks, CA.: Sage.

Tasir, Z., Abour, K.M.E.A., Halim, N.D.A., & Harun, J. (2012). Relationship between teachers' ICT competency, confidence Level, and satisfaction toward ICT training programmes: A Case study among postgraduate students. *The Turkish Online Journal of Educational Technology*, 11(1), pp. 138–144. Available at: https://files.eric.ed.gov/fulltext/EJ976576.pdf (Accessed on 23 October 2018).

Taylor, L. (2004). How student teachers develop their understanding of teaching using ICT. *Journal of Education for Teaching*: *International Research and Pedagogy*, 30(1), pp. 43-56. https://doi.org/10.1080/0260747032000162307

Taylor, S., & Todd, P. (1995). Decomposition and crossover effects in the theory of planned behaviour: a study of consumer adoption intentions. *International Journal of Research in Marketing*, 12(2), pp. 137–156. https://doi.org/10.7307/ptt.v29i1.2076

Teddlie, C., & Tashakkori, A. (2003). Major issues and controversies in the use of mixed methods in the social and behavioural sciences. In Tashakkori, A. & Teddlie, C. (Eds.), *Handbook of Mixed Methods in Social and Behavioral Research*. Thousand Oaks, CA.: Sage.

Teddlie, C., & Tashakkori, A. (2006). A general typology of research designs featuring mixed methods. *Research in the Schools*, 13(1), pp. 12-28. Available at http://www.msera.org/docs/rits-v13n1-complete.pdf (Accessed 23 June 2018).

Teddlie, C., & Tashakkori, A. (2009). *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioural Sciences*. London: Sage.

Tedla, B.A. (2012). Understanding the importance, Impacts and Barriers of ICT on Teaching and Learning in East African Countries. *International Journal for e-learning Security (JeLS)*, 2(3/4). https://doi.org/10.20533/ijels.2046.4568.2012.0025

Tella, A., Tella, A., Toyobo, O.M., Adika, L.O., & Adeyinka, A.A. (2007). An assessment of Secondary School Teachers' uses of ICTS: Implications for development of ICTs' use in Nigerian Secondary Schools. *The Turkish Online Journal of Educational Technology*, 6(3), pp. 5-17. Available at http://www.tojet.net/articles/v6i3/631.pdf (Accessed 14 November 2017).

Teo, T. (2007). Perceived importance, enjoyment, and anxiety as correlates of computer attitudes. *Psychological Reports*, 100(1), pp. 127-135. https://doi.org/10.2466/pr0.100.1.127-135

Teo, T. (2008). Pre-service teachers' attitudes towards computer use: A Singapore survey. Australasian Journal of Educational Technology, 24(4), pp. 413–424.

Teo, T. (2009). Is there an attitude problem? Reconsidering the role of attitude in the TAM. *British Journal of Educational Technology*, 40(6), pp. 1139–1141. https://doi.org/10.1111/j.1467-8535.2008.00913.x

Teo, T. (2009). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education*, 52(2), pp. 302-312. https://doi.org/10.1016/j.compedu.2008.08.006

Teo, T. (2010). A path analysis of pre-service teachers' attitudes to computer use: applying and extending the Technology acceptance model in an educational context. *Interactive Learning Environments*, 18(1), pp. 65-79. https://doi.org/10.1080/10494820802231327

Teo, T. (2012). Examining the intention to use technology among pre-service teachers: an integration of the Technology Acceptance Model and Theory of Planned Behaviour. *Interactive Learning Environments*, 20(1), pp. 3–18. https://doi.org/10.1080/10494821003714632

Teo, T., & Noyes, J. (2011). An assessment of the influence of perceived enjoyment and attitude on the intention to use technology among pre-service teachers: A structural equation modelling approach. *Computers & Education*, 57, pp. 1645-1653. https://doi.org/10.1016/j.compedu.2011.03.002

Teo, T., & Tan, L. (2012). The Theory of Planned Behaviour (TPB) and Pre-service Teachers' Technology Acceptance: A Validation Study Using Structural Equation Modeling. *Journal of Technology and Teacher Education*, 20(1), pp. 89-104. Available at https://www.learntechlib.org/primary/p/36090/ (Accessed 9 June 2018).

Teo, T., & Zhou, M. (2014). Explaining the intention to use technology among university students: A structural equation modelling approach. *Journal of Computing in Higher Education*, 26(2), pp. 124–142. https://doi.org/10.1007/s12528-014-9080-3

Teo, T., Chai, C.S., Hung, D., & Lee, C.B. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education*, 36(2), pp. 163–174. https://doi.org/10.1080/13598660801971641

Teo, T., Fan, X., & Du, J. (2015). Technology acceptance among pre-service teachers: Does gender matter? *Australasian Journal of Educational Technology*, 31(3), pp. 235-251. https://doi.org/https://doi.org/10.14742/ajet.1672

Teo, T., Lee, C.B., & Chai, C.S. (2008). Understanding pre-service teachers' computer attitudes: Applying and extending the technology acceptance model. *Journal of Computer Assisted Learning*, 24, pp. 128–143. https://doi.org/10.1111/j.1365-2729.2007.00247.x

Terada, Y. (2020). A Powerful Model for Understanding Good Tech Integration. [Online]. Available at: https://www.edutopia.org/article/powerful-model-understanding-good-tech-integration. Accessed 19 October 2021.

Terrell, S. R. (2012). Mixed-Methods Research Methodologies. *The Qualitative Report*, 17(1), pp. 254-280. https://doi.org/10.46743/2160-3715/2012.1819

The theory of planned behaviour: Reactions and reflections - Scientific Figure on ResearchGate n.d. Available from: https://www.researchgate.net/figure/Number-of-citations-of-the-TPB-in-Google-Scholar_fig1_51653805 (Accessed February 2018).

Tondeur, J., Hermans, R., Valcke, M., & Van Braak, J. (2008). Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom. *Computers in Human Behaviour*, 24(6), pp. 2541–2553. https://doi.org/10.1016/j.chb.2008.02.020

Tondeur, J., Van Braak, J., Ertmer, P.A., & Ottenbreit -Leftwitch, A. (2017). Understanding the Relationship between Teachers' Pedagogical Beliefs and Technology Use in Education: A Systematic Review of Qualitative Evidence. *Educational Research and Development*, [Online], 65(3), pp. 555–575.

Available at: https://eric.ed.gov/?id=EJ1141015 (Accessed 27 September 2017).

Tondeur, J., Van Keer, H., Van Braak, J., & Valcke, M. (2008). ICT integration in the classroom: Challenging the potential of a school policy. *Computers & Education*, 51(1), pp. 212-223. https://doi.org/10.1016/j.compedu.2007.05.003

Turner, M., Kitchenham, B., Brereton, P., Charters, S., & Budgen, D. (2010). Does the technology acceptance model predict actual use? A systematic literature review. *Information and Software Technology*, 52(5), pp. 463–479. https://doi.org/10.1016/j.infsof.2009.11.005

Tweddell Levinsen, K. (2007). Qualifying online teachers' communicative skills and their impact in e-learning quality. *Education and Information Technologies*, 12, pp. 41–51. https://doi.org/10.1007/s10639-006-9025-1

U.S. Department of Education. National Centre for Education Statistics. Teachers' tools for the 21st Century: A Report on teachers' use of technology. NECS 2013-102. Available at https://nces.ed.gov/pubs2000/2000102.pdf (Accessed 23 November 2019).

Ul Amin, S.N. (2013). An effective use of ICT for Education and learning by drawing on worldwide knowledge, research and experience: ICT act as a change agent for education (A literature review). *Scholarly Journal of Education*, 2(4), pp. 38–45. Available at: http://www.scholarly-journals.com/sje/archive/2013/April/pdf/Noor-Ul-Amin.pdf (Accessed 18 November 2018).

UNESCO, (2002). Information and Communication Technology in Education. A Curriculum for Schools and Programme of Teacher Development. Paris: UNESCO. Available at http://www.ifip-tc3.net/IMG/pdf/unesco-ifip_wg3.1-129538e.pdf (Accessed 20 September 2018).

UNSW teaching, (2018). Simulations. [Online]. Available at: https://teaching.unsw.edu.au/simulations (Accessed 12 July 2019).

Van Braak, J. (2003). Opstellen van beleidsplannen voor ICT in het onderwijs. In *ICT en Onderwijshernieuwing: Schoolleiding En Begeleiding* (pp. 67-82). Mechelen: Wolters Plantyn.

Van Rij, V.and Warrigton, B. (2010). Teaching and learning for an ICT revolutionized society. Available at https://farhorison.portals.mbs.ac.uk. (Accessed 20 September 2018).

Vanderlinde, R., Van Braak, J., & Dexter, S. (2012). ICT policy planning in a context of curriculum reform: Disentanglement of ICT policy domains and artefacts. *Computers & Education*, 58(4), pp. 1339-1350. https://doi.org/10.1016/j.compedu.2011.12.007

Vanderlinde, R., Van Braak, J., & Hermans, R. (2009). Educational technology on a turning point: Curriculum implementation in Flanders and challenges for schools. *Educational Technology Research & Development*, 57, pp. 573–584. https://doi.org/10.1007/s11423-009-9126-9

Vandeyar, T. (2013). Practice as Policy in ICT for Education: Catalysing communities of practice in education in South Africa. Available at http://hdl.handle.net/2263/42311 (Accessed 23 November 2019)

Venkatesh, V., & Davis, F.D. (1996). A model of the antecedents of perceived ease of use: development and test. *Decision Sciences,* 27(3), pp. 451–481. https://doi.org/10.1111/j.1540-5915.1996.tb00860.x

Venkatesh, V., & Davis, F.D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46, pp.186–204. Available at https://www.jstor.org/stable/2634758 (Accessed 17 May 2018).

Venkatesh, V., & Morris, M.G. (2000). Why Don’t Men Ever Stop to Ask for Directions? Gender, social influence, and their role in technology acceptance and usage behaviour. MIS Quarterly, 24(1), pp. 115-139. https://doi.org/10.2307/3250981

Venkatesh, V., & Speier, C. (1999). Computer Technology Training in the Workplace: A Longitudinal Investigation of the Effect of Mood. *Organizational Behaviour and Human Decision Processes*, 79(1), pp. 1-28. https://doi.org/10.1006/obhd.1999.2837

Venkatesh, V., Brown, S. A. & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in Information Systems. *MIS Quarterly*, 37(1), pp. 21 – 54.

Venkatesh, V., Brown, S.A., Maruping, L.M., & Bala, H. (2008). Predicting different conceptualizations of system use: The competing roles of behavioural intention, facilitating conditions, and behavioural expectation. *MIS Quarterly*, 32(3), pp. 483–502. https://doi.org/10.2307/25148853

Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), pp. 425–478. https://doi.org/10.2307/30036540

Visser, P.S., Krosnick, J.A., & Lavrakas, P.J. (2000). Survey research. Available at: http://web.stanford.edu/dept/communication/faculty/krosnick/Survey_Research.pdf (Accessed 4 June 2018).

Warshaw, P.R., & Davis, F.D. (1985a). Disentangling behavioural intention and behavioural expectation. *Journal of Experimental Social Psychology*, 21(3), pp. 213–228. https://doi.org/10.1016/0022-1031(85)90017-4

Warshaw, P.R., & Davis, F.D. (1985b). The accuracy of behavioural intention versus behavioural expectation for predicting behavioural goals. *Journal of Psychology*, 119(6), pp. 599–602. https://doi.org/10.1080/00223980.1985.9915469

Weaver, C. (2005). What encourages student participation in online discussions? Unpublished PhD thesis, University of Southern Queensland, Towomba, Australia. Available at https://eprints.usq.edu.au/1523/ (Accessed 11 December 2017).

Western Cape Provincial Government. (2004). ICT professional development for management, teaching and learning. (Provincial Government Gazette, no 26734). Available at https://www.westerncape.gov.za/Text/2004/11/chapter5_26734.pdf (Accessed 23 October 2017).

Willis, J. W. (2007). Foundations of qualitative research: Interpretive and critical approaches. Thousand Oaks, CA: Sage Publications.

Wilson-Strydom, M. (2004). *Evaluation of Intel® Teach to the Future in South Africa. Year One Evaluation. Report prepared for SchoolNet SA and Intel® Teach to the Future in South Africa*. Johannesburg: Neil Butcher and Associates.

Wilson-Strydom, M. (2005). *Evaluation of Intel® Teach to the Future in South Africa. Year Two Evaluation. Report prepared for SchoolNet SA and Intel® Teach to the Future in South Africa*. Johannesburg: Neil Butcher and Associates.

Wilson-Strydom, M., & Thomson, J. (2008). How has Intel® Teach to the Future worked in South Africa? The answer is in the question. Paper prepared for submission to Perspectives in Education, Special Edition Education in South Africa: what have Information and Communication Technologies got to do with it? Johannesburg: Neil Butcher and Associates. Available at: http://www.schoolnet.org.za/reports/archive_pre07/wcce_ttf_paper.doc (Accessed 20 November 2017).

Wilson-Strydom, M., & Thomson, J. (2005). Understanding ICT integration in South African Classrooms. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.458.4592&rep=rep1&type=pdf (Accessed 20 November 2017).

Winslow, J., Dickerson, J., Weaver, C., & Josey, F. (2016). Iterative and event-based frameworks for university and school district technology professional development partnerships. *TechTrends*, 60(1), pp. 56–61. https://doi.org/10.1007/s11528-015-0017-0

Wood, E., Mueller, J., Willoughby, T., Specht, J., & Deyoung, T. (2005). Teachers’ perceptions: Barriers and supports to using technology in the classroom. *Education, Communication and Information*, 5, pp. 183–206. https://doi.org/10.1080/14636310500186214

World. Program Profile. (2001). World: Teacher Professional Development as the Cornerstone of Educational ICT Use: No author. pp 23. [Online]. Available at: http://www.saigontre.com/FDFiles/ICT_in_Education.PDF (Accessed 10 November 2017).

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and Teacher Education,* 14(1), pp. 173-207. Available at https://www.learntechlib.org/primary/p/5437/ (Accessed 11 December 2017).

Yahya, F.H. (2019). Teaching innovation with ICT. *Proceeding International Seminar of Primary Education*, 2, pp. 7–9. Available at http://prosiding.unipma.ac.id/index.php/ISPE/article/download/1240/987 (Accessed 8 July 2020).

Yerrick, R K., & Hoving, T.J. (2003). One foot on the dock and one foot on the boat: Differences among preservice science teachers' interpretations of field-based science methods in culturally diverse contexts. *Science Education*, 87, pp. 390–418, https://doi.org/10.1002/sce.10057

Yucel, U.A., & Gulbahar, Y. (2013). Technology Acceptance Model: A Review of the Prior Predictors. *Journal of Faculty of Educational Sciences*, 46(1), pp. 89-109. https://doi.org/10.1501/Egifak_0000001275

Yuen, A.H.K., & Ma, W.W.K. (2002). Gender differences in teacher computer acceptance. *Journal of Technology and Teacher Education*, 10(3), pp. 365–382. Available at https://www.learntechlib.org/primary/p/15142/ (Accessed 2 August 2017).

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. (2002). Conditions for classroom technology innovations. *Teachers College Record*, 104(3), pp. 482- 515.

Zhao, Y., & Frank, K.A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal*, 40, pp.807–840. https://doi.org/10.3102/00028312040004807

Zolait, A. S. (2014). The nature and components of perceived behavioural control as an element of theory of planned behaviour. *Behaviour & Information Technology*, 33, pp. 65–84. https://doi.org/10.1080/0144929X.2011.630419

APPENDICES

APPENDIX 1: ICT BELIEFS AND USAGE PRE-QUESTIONNAIRE

Teacher's name: ________________________ School: ______________________

I give permission for this information to be used for research purposes as long as this is done anonymously and the information is not used to harm me in any way.

Yes ☐ No ☐

	Strongly Agree: 5	Agree 4	Neither agree nor disagree 3	Disagree 2	Strongly Disagree: 1
Using ICT will/has improved my teaching.					
Using simulations will/has improved my teaching.					
Using **videos** will/has improved my teaching.					
Good use of ICT makes learning very **interesting.**					
Good use of ICT makes learners learn **better.**					
Using ICT in teaching **saves time.**					
My **principal expects** me to use ICT in my teaching.					
My **principal encourages** me to use ICT in my					

teaching.					
My **learners want** me to use ICT in my teaching.					
I **know** how to use a **data projector / Smartboard** for teaching. I feel confident to do this.					
I **know** how to get **learners** to use **computers** in my teaching. I feel confident to do this.					
I **know** how to get **learners** to use **tablets or cell phones** in my teaching. I feel confident to do this.					
I have **easy access** to a computer **every day.**					
I have **easy access** to a **data projector / Smartboard** for teaching every day.					
I have **easy access** to **computers for learner** use in my teaching. I do use these for teaching.					
I have **easy access** to **tablets for learner** use in my teaching. I do use these for teaching.					
Learners have **easy access** to **cell phones for learner** use. I do use these for teaching.					
I have **easy access** to someone at school who can **help me with ICT-problems.**					
I use ICT in my lesson preparation.					
I use a computer in my teaching.					

I use a data projector / Smart board in my teaching.					
I get **learners** to **use computers** in my teaching.					
I get learners to use tablets/cell phones in my teaching.					
I always use a computer for **admin** (e.g. entering marks / setting tests).					
I use **email.**					
I use the **internet**.					
I use my cell phone to go on the internet					
I need help with: (continue on back if necessary)					

APPENDIX 2: ICT BELIEFS AND USAGE POST-QUESTIONNAIRE

Thank you for taking your precious time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness responses will be greatly appreciated.

I give permission for this information to be used for research purposes as long as this is done anonymously and the information is not used to harm me in any way. Yes ☐ No ☐

Section A

Demographic Information

Teacher's name: Mr/Mrs/Ms ____________________ School: ______________________

Age range **(Tick)**

20 and below	
21 – 25	
26 – 30	
31 – 35	
36 – 40	
41 – 45	
46 – 50	
51 – 55	
56 and above	

Qualifications **(Tick)**

PGCE	
PGCE/HDE/HOD	
BSc	
BSc(Hons)	
BEd	
BEd(Hons)	
MED	
PhD	
Other	

If you chose other please provide more details

Your teaching experience

How many years have you taught grade 10 Physical Sciences?

About your school

What is your school quintile? (Tick)

1 (Very poorly resources)	
2	
3	
4	
5 (Highly resourced)	

Where is your school situated? (Tick)

Rural	
Urban	
Township	
Other	

How many working computers does your school have for use by learners? (Tick)

None	
1-5	
11-15	
16-20	
21-25	
26-30	
31-40	
41+	

Section B

	Strongly Agree: 5	Agree 4	Neither agree nor disagree 3	Disagree 2	Strongly Disagree: 1
Using ICT will/has improved my teaching.					
Using simulations will/has improved my teaching.					
Using **videos** will/has improved my teaching.					
Good use of ICT makes learning very **interesting.**					
Good use of ICT makes learners learn **better.**					
Using ICT in teaching **saves time.**					
My **principal expects** me to use ICT in my teaching.					
My **principal encourages** me to use ICT in my teaching.					
My **learners want** me to use ICT in my teaching.					
I **know** how to use a **data projector / Smartboard** for teaching. I feel confident to do this.					
I **know** how to get **learners** to use **computers** in my teaching. I feel confident to do this.					
I **know** how to get **learners** to use **tablets or cell phones** in my teaching. I feel confident to do this.					
I have **easy access** to a computer **every day.**					
I have **easy access** to a **data projector / Smartboard** for teaching every day.					

I have **easy access** to **computers for learner** use in my teaching. I do use these for teaching.					
I have **easy access** to **tablets for learner** use in my teaching. I do use these for teaching.					
Learners have **easy access** to **cell phones for learner** use. I do use these for teaching.					
I have **easy access** to someone at school who can **help me with ICT-problems.**					
I use ICT in my lesson preparation.					
I use a computer in my teaching.					
I use a data projector / Smart board in my teaching.					
I get **learners** to **use computers** in my teaching.					
I get learners to use tablets/cell phones in my teaching.					
I always use a computer for **admin** (e.g. entering marks / setting tests).					
I use **email.**					
I use the **internet**.					
I use my cell phone to go on the internet					
I need help with: (continue on back if necessary)					

APPENDIX 3: CLASSIFICATION OF PRE AND POST QUESTIONNAIRE

Construct	Example
Perceived Usefulness (Adapted from Davis (1989)	Using computers will/has improve(d) my work. **(PU1)** Using simulations will/has improve(d) my teaching. (PU2) Using **videos** will/has improve(d) my teaching. **(PU3)** Good use of ICT makes learning very **interesting (PU4).** Good use of ICT makes learners learn **better (PU5).** Using ICT in teaching **saves time (PU6).**
Perceived Ease of Use (Adapted from Davis et al. 1992)	I **know** how to use a **data projector/Smartboard** for teaching. I feel confident to do this. **(PEU1)** I **know** how to get **learners** to use **computers** in my teaching. I feel confident to do this**. (PEU2)** I **know** how to get **learners** to use **tablets or cell phones** in my teaching. I feel confident to do this. (PEU3)
Usage	I use ICT in my lesson preparation. (U1) I use a computer in my teaching. (U2) I use a data projector/Smart board in my teaching. (U3) I get **learners** to **use computers** in my teaching. (U4) I get learners to use tablets/cell phones in my teaching. (U5) I always use a computer for **admin** (e.g. entering marks/setting tests). **(U6)** I use email. (U7) I use the **internet**. (**U8)** I use my cell phone to go on the internet. (U9)
Perceived Behavioural	I have easy access to a data projector/Smartboard for

Control (Adapted Thompson, Higgins & Howell 1991)	teaching every day. (PBC2) I have **easy access** to **computers for learner** use in my teaching. I do/could use these for teaching. **(PBC3)** I have **easy access** to **tablets for learner** use in my teaching. I do/could use these for teaching. (PBC4) Learners have **easy access** to **cell phones for learner** use. I do/could use these for teaching. (PBC5) I have easy access to someone at school who can help me with ICT-problems. (PBC6)
Subjective norm (adapted from Ajzen (1991); Davis et al. (1989))	My **principal expects** me to use ICT in my teaching. **(SN1)** My **principal encourages** me to use ICT in my teaching. **(SN2)** My **learners want** me to use ICT in my teaching. **(SN3)**

APPENDIX 4: VARIOUS ASPECTS OF THE PROGRAMME

Thank you for taking your precious time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness responses will be greatly appreciated.

I give permission for this information to be used for research purposes as long as this is done anonymously, and the information is not used to harm me in any way.

Yes ☐ No ☐

Section A

	Strongly disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly agree 5
The Short Learning Programme illustrated effective use of ICTs in the teaching of Physical Sciences.					
The SLP methodology changed my belief towards ICTs usage.					
The content of the SLP allow ICTs implementation in my daily practice.					
The posts on the WhatsApp group made me want to use ICT in my teaching.					
Through WhatsApp I could easily get technical help when I needed it.					
Classroom interactions built my confidence in the use of ICTs.					
SLP changed the chalk and board belief I had in the teaching and learning of Physical Sciences.					

Learners' attitudes towards Physical Sciences has changed.					
The Wi-Fi problems we had in this SLP made me distrust using ICTs in teaching and learning.					
Navigating through the tablet discouraged me in using ICTs in the teaching and learning.					
Too much content was taught in a short space of time such that I more often got confused.					
I am still not confident in using ICTs in my Physical Sciences class.					

Section B

What aspects (if any) of the programme made you to use ICTSs in your teaching and learning?

____

What aspects (if any) of the discouraged you to use ICTSs in your teaching and learning?

____

APPENDIX 5: INTERVIEW PROTOCOL 1

Introduction (3 minutes)	Thank you for agreeing to meet with me. I am Modie Mafojane, I am currently a student at the University of the Free State studying PhD. I am also an employee of the Free State Department of Education. Kindly take note that the semi-structured interviews I will be conducting with you is not for the Free State Department of Education but it is for my PhD studies. The purpose of this interview is to help me better understand how did various aspects of the programme you attended influenced your beliefs and practices regarding use of Information and communication technologies. I will treat your answers as confidential. I will not include your name or any other information that could identify you in any report I will write. I will destroy the notes and audiotapes after I complete my study.
General	● Why did you participate in this programme? ● What was the results/impact of your participation?**(Opinion and Value)** ● Did the programme meet your **expectation**s? What were your **expectations**? **(Opinion and Value)** ● What are you doing today in your classroom that you did not do prior to this programme? **(Experience and Behaviour)** ● After the programme do you think or do not think use of ICTs is doable/not doable? What are reasons behind your thought? **(Opinion and Value)** ● In what way was this programme useful to you? **(Opinion and Value)**
Scope of the Training	Did the training meet your **needs**? What were your **needs**?
	What **skills** did you learn in this programme? **(Knowledge)**
	What new practice (s) will you implement as a result of this programme?

	(Knowledge)
	Are you implementing the new practices?
	What will it take for you to implement the new practices/skills in this programme?
	What specific assistance would be helpful to you in implementing the new practices presented in this programme?
	What practices you currently use will be discontinued as a result of this programme?
Resources (Tablet):	Was the tablet user friendly?
	What are the main challenges you experienced when using the tablet?
	Could you access the loaded information easily/with difficulty?
Duration	Was the duration enough to make you understand the contents of the programme?
	Given the duration of the programme, will you be able to implement what you learned?
	Did the duration of the programme in any way disadvantaged you? How did it disadvantage you?
Participant's Opinion	What are the strengths of this programme?
	What are the weaknesses of this programme
	How would you like the programme to be conducted in future?

APPENDIX 5.1: INTERVIEW PROTOCOL 2

Introduction (3 minutes)	Thank you for agreeing to meet with me. I am Modie Mafojane, I am currently a student at the University of the Free State studying PhD. I am also an employee of the Free State Department of Education. Kindly take note that the semi-structured interviews I will be conducting with you is not for the Free State Department of Education but it is for my PhD studies. The purpose of this interview is to help me better understand how teachers' beliefs and practices regarding use of ICTs changed during the programme and how various factors (prior beliefs, prior ICT, age qualification and school environment) affected the extent at which teachers' beliefs and practices regarding use of ICTs in the teaching of Physical Sciences change during the programme. I will treat your answers as confidential. I will not include your name or any other information that could identify you in any report I will write. I will destroy the notes and audiotapes after I complete my study.
Before the programme	
Prior usage (10 minutes)	Do you have computers/laptops at your school?
	Do you have access and what are you using them for?
	Have you used the computer/tablet before in the teaching of Physical Sciences?
	How often were you using the computers/tablet/laptops in the teaching of Physical Sciences?
	Did the use of computers/tablet/laptops helped you to explain the particular topic in Physical Sciences better?
	Briefly explain how did the use of computers/tablet/laptops helped you

	in teaching the specific topic in Physical Sciences better?
	Was it easy or difficult to use computers/tablet/laptops to teach Physical Sciences?
Prior Beliefs and Practice (5 minutes)	What is your general perception towards use of computers/laptops in teaching?
	Do you think use of computers/tablet/laptops would make the teaching of Physical Sciences easy/difficult/interesting?
	Do you think use of computers/tablet will help you to cover all the prescribed curriculum?
	Do use of computers make your lesson planning easy/difficult/interesting?
After the programme	
Beliefs and Practice (10 minutes)	What is your general perception towards use of computers/laptops in teaching? ● Do you know how to get learners to use computers/laptops/tablet? How confident are you? ● Do you know how to get learners to use computers/laptops/tablet in your teaching?
	Do you use computers/tablet/laptops in your lesson preparation?
	Do you use computers/tablet/laptops in your teaching? How often?
	What are you using computers/tablet/laptops for during your teaching?
	Has your teaching improved? How did it improve?

	Do use of computers/tablet/laptops make the teaching of Physical Sciences easy/difficult/interesting?
	How do computers/tablet/laptops make the teaching/learning of Physical Sciences easy/difficult/interesting?
Usage (5 minutes)	How confident are you to use computers/tablet/laptops in your Physical Sciences teaching? ● Can you now use computer/tablet/laptop to teach Physical Sciences? What are you using computers/tablet/laptop mainly for?
	How often are you using the computers/tablet/laptops in the teaching of Physical Sciences?
	Is it time consuming to use computers/tablet/laptops in the teaching of Physical Sciences?
	Do the use of computers/tablet/laptops impacted negatively/positively on learners?
Final Thoughts (3 minutes)	These were all the questions I wanted to ask. Do you have any final thoughts about what we discussed that you would like to share? Thank you for your time

APPENDIX 6: OBSERVATION SHEET

Programme: To what extend does the programme address the identified need?

Is the programme taking place as originally intended? Or is the programme being implemented as planned?

Resources

Are participants given the required resources needed to achieve intended goals?

Are participants equipped on how to use the resource?

Are they able to use the resource?

Tasks

Are tasks objectives clear?

Are there enough instructions to guide participants when performing tasks?

Are participants able to complete given tasks on time?

Facilitator

Is the objective of the session explained well to the participants?

Is the facilitator clear during instruction?

Does the facilitator make it easy for participants to ask questions for clarity/say comments during the sessions?

Engagement/Participation

What is the general attitude of participants during sessions?

Are participants able to navigate through the tablet?

Are participants' asking questions for clarity?

Are participants' able to tell when they do not understand?

Are participants' doing their homework's or any other task they needed to do as per the requirement?

Do participants show commitment to the programme?

Performance

What is the performance of participants during tests?

General Observation

To what extent is the programme achieving the intended outcomes, in the short term?

To what extent is the programme producing worthwhile results (outputs, outcomes) and/or meeting each of its objectives?

Does the programme meet the participant's needs?

Are participants being reached as intended?

How satisfied are programme participants?

APPENDIX 7: FINAL ASSESSMENT TASK INSTRUCTIONS

Name:

School:

Student number:

What did you do?

Details list

Teaching strategy:

Grade:

Topic:

Date(s):

Description

Describe what you did:

Documentation

Give names of the files you have uploaded in your folder in the Gr10PSSLP google drive:

Worksheets:

Photos:

Videos:

What were your expectations?

Justification for the teaching strategy with reference to teaching and learning theory

Describe why you thought the strategy you used and the way you used it would lead to effective learning. Refer to relevant learning and teaching theory. Make sure your answer demonstrates that you understand the required prior knowledge and you are aware of the learners' age and the context in which this occurred.

What happened in class?

Description

Describe what happened: how learners responded, were expectations met, what worked well, what did not work well.

Analysis and interpretation

Give insightful suggestions for reasons for the observed outcome of the teaching strategy. Make sure you demonstrate that you understand principles of learning and teaching and demonstrate deep thought and metacognition.

What are your self-reflections?

What have you learnt from this experience? How will it affect the way you teach in the future?

APPENDIX 8: FINAL ASSEMENT RUBRIC

Assessment /25

	2	1	0
	What was done		
List		Clear list of the grade, topic, teaching strategy and dates.	Not clear or incomplete
Description	Clear and relevant description of what was done.	Somewhat clear and relevant description of what was done.	Description poor, irrelevant, or incomplete.
Documentation	Extensive and relevant documentation (video, photos, worksheets).	Some relevant documentation.	Inappropriate or insufficient documentation.
	4 3	2 1	0
	Expectations		
Justification for teaching strategy	An insightful motivation for using the teaching strategy in the given context. This demonstrates that the student understands the required prior knowledge, is aware of the learners' age and context, and understands principles of	The student's motivation is fair, or good but slightly incomplete.	The student's work is very poor, or largely incomplete.

	learning and teaching.		
Reference to teaching and learning theories	An accurate, insightful, and relevant summary of a teaching / learning theory, with justification of use of the teaching strategy in terms of this teaching / learning theory.	The student's summary of, and link to, teaching/learning theory is fair, or good but slightly incomplete, or good but lacking clear linkage between theory justification.	The student's work is very poor, or largely incomplete.
	What happened in class		
	2	1	0
Description	Clear and relevant description of what happened: how learners responded, were expectations met, what worked well, what did not work well.	Somewhat clear and relevant description of what was done.	Description poor, irrelevant, or incomplete.
	4 3	2 1	0

Analysis and interpretation	An insightful suggestion of reasons for the observed outcome of the teaching strategy. This demonstrates that the student understands principles of learning and teaching and demonstrates deep thought and metacognition.	The student's discussion is fair, or good but slightly incomplete.	The student's work is very poor, or largely incomplete.
	Self-reflection		
Self-reflection	Critical and personal reflection. From this insightful conclusions are drawn about learning and teaching.	The student's self-reflection is fair, or good but slightly incomplete.	The student's work is very poor, or largely incomplete.
	Overall impression		
	2: Excellent	1: Good	0: Fair / poor

APPENDIX 9: TABLES USED TO MODERATE FINAL ASSESSMENT TASK

Appendix 9, Table 1: Teachers that used the six TPACK components to design technology-based lessons.

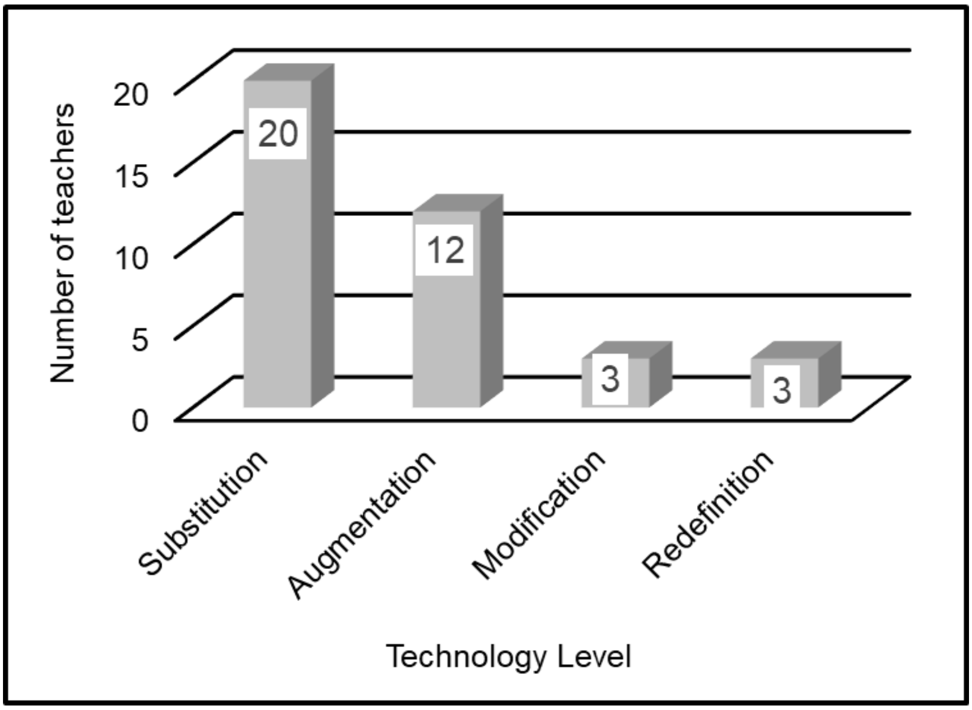
Component of TPACK	Activity	Number of lessons
TK: Knowledge of old and new technology tools including hardware and software, how to install and operate them and how to trouble shoot)	Used: Share it, Navigation of the tablet, videos, PowerPoint, Kahoot, and Edukite programme	38
TCK: Knowledge of technological tools suited to represent specific subject content	**Used PowerPoints**: learners to speak and understand Chemistry, teach forces, periodicity, electrons, **Used video**: video to teach stoichiometry, teach learners solubility of salts, share video of resistance prior teaching (Flipped Classroom) and guided simulation, simulation to discover ohm's law, **Used Simulation to**: build electric circuits in order to discover ohm's law, teach electric circuits **Used video, simulations and quizzes** to introduce grade 10 Electric circuits whilst starting from what learners know **Used Kahoot** to teach organic molecules **Direct measurement video** to measure speed of a ping-pong ball	38
TPK: Knowledge of particular tools, the educational uses they are suited to and how to use them, including tools for record-keeping, interacting	PowerPoint and inquiry based learning, PowerPoint and analogy, Simulation and inquiry based learning, Simulation and problem solving, Direct measurement video and problem solving, Drill and practice and PowerPoint,	38
PCK: Knowledge of the best teaching and learning approaches to promote understanding of specific subject content taught	Inquiry based learning to teach Ohm's Law, Drill and practice to teach electric circuits, Problem solving method to teach electric circuits, Direct measurement video to calculate the speed of the pin-pong ball and quizzes to answer questions on electric circuits, organic molecules and vectors	38
PK: knowledge of variety of generic teaching	Inquiry based learning, Discovery based learning, Drill and practice, Problem	38

methods	Solving and Drill and practice	
CK: knowledge of subject matter to be taught	Organic molecules, vectors, electromagnetic induction and electric circuits.	

Appendix 9, Table 2: Teachers that used PCK, PK and CK components of TPACK to design technology-based lessons.

Component of TPACK	Activity	Number of lessons
PCK: Knowledge of the best teaching and learning approaches to promote understanding of specific subject content taught	Chalk and board to teach electromagnetic induction, Problem solving method to calculate resistance, drill and practice to memorize organic molecules and	11
PK: knowledge of variety of generic teaching methods	Chalk and board, problem solving, drill and practice	11
CK: knowledge of subject matter to be taught	Electromagnetic induction, Calculate resistance and organic molecules	11

APPENDIX 10: TECHNOLOGY LEVELS OF 38 TEACHERS



Appendix 10, Figure 1: Technology levels of 38 teachers

APPENDIX 11: CODES

Appendix 11, Table 1: Codes used during data analysis

Name	Files	References	Created On	Created By	Modified On	Modified By
TPACK	0	0	8/27/2018 4:53 AM	MAJ	8/27/2018 4:53 AM	MAJ
TK	6	76	8/27/2018 4:53 AM	MAJ	9/11/2018 11:11 AM	MAJ
CK	4	5	8/27/2018 4:53 AM	MAJ	9/8/2018 7:15 PM	MAJ
PK	3	28	8/27/2018 4:53 AM	MAJ	9/7/2018 3:13 PM	MAJ
TPK	6	62	8/27/2018 4:53 AM	MAJ	9/11/2018 10:49 AM	MAJ
TCK	4	12	8/27/2018 4:54 AM	MAJ	9/8/2018 7:23 PM	MAJ
PCK	3	9	8/27/2018 4:54 AM	MAJ	9/7/2018 4:51 PM	MAJ
Issues	0	0	8/27/2018 4:54 AM	MAJ	8/27/2018 4:54 AM	MAJ
Expectations	0	0	8/27/2018 4:55 AM	MAJ	8/27/2018 4:55 AM	MAJ
PE	6	126	8/27/2018 4:55 AM	MAJ	9/11/2018 9:26 AM	MAJ
NE	6	49	8/27/2018 4:55 AM	MAJ	9/11/2018 11:06 AM	MAJ
Technical	0	0	8/27/2018 4:55 AM	MAJ	8/27/2018 4:55 AM	MAJ
PT	5	26	8/27/2018 4:55 AM	MAJ	9/8/2018 6:48 PM	MAJ
NT	6	27	8/27/2018 4:56 AM	MAJ	9/11/2018 11:06 AM	MAJ
School Issues	0	0	8/27/2018 4:56 AM	MAJ	8/27/2018 4:56 AM	MAJ
PSI	5	79	8/27/2018 4:57 AM	MAJ	9/8/2018 7:18 PM	MAJ
NSI	6	77	8/27/2018 4:57 AM	MAJ	9/11/2018 9:44 AM	MAJ
RCP	4	14	9/3/2018 11:17 AM	MAJ	9/11/2018 11:04 AM	MAJ
PrePost	0	0	8/29/2018 2:39 PM	MAJ	8/29/2018 2:39 PM	MAJ
Pre	6	85	8/29/2018 2:39 PM	MAJ	9/11/2018 9:11 AM	MAJ
Post	6	186	8/29/2018 2:40 PM	MAJ	9/11/2018 11:14 AM	MAJ
Teacher Categorization	0	0	9/3/2018 2:00 PM	MAJ	9/3/2018 2:00 PM	MAJ
Step by Step	5	13	9/3/2018 2:01 PM	MAJ	9/11/2018 11:03 AM	MAJ
Transitional	5	52	9/3/2018 2:01 PM	MAJ	9/11/2018 9:16 AM	MAJ
Independent	5	57	9/3/2018 2:01 PM	MAJ	9/11/2018 9:26 AM	MAJ

Name	Files	References	Created On	Created By	Modified On	Modified By
SAMR	0	0	8/27/2018 4:40 AM	MAJ	8/27/2018 4:40 AM	MAJ
S	4	31	8/27/2018 4:41 AM	MAJ	9/12/2018 3:45 PM	MAJ
A	5	34	8/27/2018 4:41 AM	MAJ	9/12/2018 3:45 PM	MAJ
M	5	30	8/27/2018 4:41 AM	MAJ	9/12/2018 3:45 PM	MAJ
R	2	8	8/27/2018 4:41 AM	MAJ	9/12/2018 3:39 PM	MAJ
TPB	0	0	8/27/2018 4:45 AM	MAJ	8/27/2018 4:45 AM	MAJ
A	0	0	8/27/2018 4:45 AM	MAJ	8/27/2018 4:45 AM	MAJ
PBO	6	190	8/27/2018 4:45 AM	MAJ	9/11/2018 11:14 AM	MAJ
NBO	6	85	8/27/2018 4:46 AM	MAJ	9/11/2018 11:12 AM	MAJ
V	0	0	8/27/2018 4:46 AM	MAJ	8/27/2018 4:46 AM	MAJ
CC	5	67	8/27/2018 4:46 AM	MAJ	9/8/2018 7:24 PM	MAJ
T	6	130	8/27/2018 4:46 AM	MAJ	9/11/2018 11:13 AM	MAJ
CK	4	47	8/27/2018 4:46 AM	MAJ	9/8/2018 3:02 PM	MAJ
SN	0	0	8/27/2018 4:48 AM	MAJ	8/27/2018 4:48 AM	MAJ
PSN	5	94	8/27/2018 4:48 AM	MAJ	9/8/2018 6:33 PM	MAJ
NSN	6	77	8/27/2018 4:49 AM	MAJ	9/11/2018 11:08 AM	MAJ
PBC	0	0	8/27/2018 11:34 AM	MAJ	8/29/2018 2:37 PM	MAJ
PPBC	5	129	8/29/2018 3:04 PM	MAJ	9/8/2018 6:44 PM	MAJ
NPBC	6	67	8/29/2018 3:06 PM	MAJ	9/11/2018 11:08 AM	MAJ
TAM	0	0	8/27/2018 4:52 AM	MAJ	8/27/2018 6:31 PM	MAJ
PEU	6	121	8/27/2018 4:52 AM	MAJ	9/11/2018 9:49 AM	MAJ
PU	5	128	8/27/2018 4:53 AM	MAJ	9/8/2018 7:24 PM	MAJ

APPENDIX 12: PERMISSION FROM PROGRAMME MANAGER TO CONDUCT RESEARCH

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
SOUTH CAMPUS / SUID-KAMPUS

UFS UV

TO WHOM IT MAY CONCERN

I hereby grant permission to Me MAJ Mafojane, student number 2007088434, to conduct research on the *Grade 10 Physical Science: Teaching and Content* Short Learning Programme.

All research must adhere to the appropriate rules and regulations of the UFS.

Yours sincerely

....

Mr HA Dreyer
Head: Short Learning Programmes

APPENDIX 13: APPROVAL FROM FSDOE TO CONDUCT RESEARCH

education
Department of Education
FREE STATE PROVINCE

Enquiries: BM Kitching
Ref: Research Permission: MAJ Mafojane
Tel. 051 404 9283 / 9221 / 082 454 1519
Email: berthakitching@gmail.com and B.Kitching@edu.fs.gov.za

MAJ Mafojane
18 Wisteria Flats
First Street, **BLOEMFONTEIN, 9301**

083 477 2911

Dear Mrs Mafojane

APPROVAL TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

1. This letter serves as an acknowledgement of receipt of your request to conduct research in the Free State Department of Education.

   Research Topic: Promoting teachers' usage of information and communication technologies in some selected South African schools.

   Schools: Xhariep District: 3 schools: Beang Tse Molemo, Boaramelo, Ikanyegeng
   Motheo District: 36 schools: Albert Moroka, Bainsvlei Combined, Bloemfontein SH, Commtech, Goronyane, Hodisa, HTS Louis Botha, Kagisho, Kaelang, Khauho, Lereko, Lefikeng, Leratong, Lekhulong, Lenyora La,Thuto, Louw Wepener, Mariasdaal, Ntemoseng, Ntumediseng, Qibing, Reamohetse,, Reutlwhetse, RT Mokgopa, San Du Plessis, Seemahale, Sediti, Sehunelo, Sentraal High, Setjhaba Se Maketse, Strydom, St Michael's, Thato, Tsoseletso, Tlotlanang, Tweespruit CS, Vulamasango
   Lejweleputswa District 12 schools: HTS Welkom, Kheleng, Mamellang Thuto, Matseripe, Rainbow,, Reatlehile, Refihletse CS, Rheederpark, Senzile, Taiwe, Welkom High, Welkom Secondary

   Target Population: 86 Grade 10 Physical Science teachers from the schools above.

2. **Period of research**: From the date of signature of this letter until 30 September 2018. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours.

3. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension.

4. The approval is subject to the following conditions:

   4.1 The collection of data should not interfere with the normal tuition time or teaching process.
   4.2 A bound copy of the research document or a CD, should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.
   4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
   4.4 The attached ethics documents must be adheared to in the discourse of your study in our department.

5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely

DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 07/02/2018

RESEARCH APPLICATION MAJ MAFOJANE PERMISSION EDITED JAN 2018
Strategic Planning, Policy & Research Directorate
Private Bag X20565, Bloemfontein, 9300 - Room 318, Old CNA Building, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9221 **Fax:** (086) 6678 678

APPENDIX 14: GOOD POWERPOINT PRINCIPLES

Good PowerPoint principles

- Redundancy principle: Narration + animation Principles for reducing extraneous cognitive processing (reducing distractions):
    - *Coherence* principle: Exclude extraneous material
    - *Signalling* principle: Highlight essential material
    - *Spatial contiguity* principle: Place corresponding words and pictures near each other
    - *Temporal contiguity* principle: Present corresponding narration and pictures simultaneously
    - better than narration, animation + text
    - Principles for managing essential cognitive processing (enhancing selecting processing):
    - *Segmenting* principle: Break presentation into learner-paced segments
    - *Pre-training* principle: Precede presentation in training in names and characteristics of key components
    - *Modality* principle: Speak, rather than print words
- Principles for fostering generative cognitive processing (enhancing sense-making (organising and integrating) processing):
    - *Multimedia* principle: Words + pictures better than words only
    - *Personalization* principle: Conversational style better than formal style
    - *Voice* principle: Human, rather than machine voice. Use of appropriate intonation, expression and variation of pace and volume, for interest.

APPENDIX 15: ANCOVA

Appendix 15, Table 1: Analysis of perceived usefulness covariance (ANCOVA) of post-pre differences with regard to biographic factors (n=53)

Dependent Variable	Demographic factor	Factor level	Mean difference: Post – Pre			
			Point Estimate[1]	F-statistic[2]	Degrees of freedom[2]	P-value[2]
Perceived Usefulness	Age group	21-35 yrs	-0.08	2.74	2. 49	0.0744
		36-50 yrs	-0.35			
		>50 yrs	-0.55			
	Gender	Female	-0.26	0.03	1. 50	0.8628
		Male	-0.23			
	Qualification	BSc/Hons	-0.12	1.04	1.50	0.3130
		Non-BSc	0.3			
	Teaching Experience	1-5	-0.12	4.28	3.48	0.0093
		6-10	0.04			
		11-20	-0.40			
		>21	-0.74			
	School Location	Rural	-0.19	0.28	2.49	0.7567
		Township	-0.33			
		Urban	-0.23			
	School Quintile	1-3	-0.21	0.63	1.50	0.4325
		4-5	0.14			

[1]Point estimate of the mean difference "post-Pre".

[2]Overall F-test, degrees of freedom and P-value for the null-hypothesis that the effect of the demographic factor in question on the post-pre difference is zero.

Appendix 15, Table 2: Analysis of perceived ease of use covariance (ANCOVA) of post-pre differences with regard to biographic factors (n=53)

Dependent Variable	**Demographic factor**	**Factor level**	**Mean difference: Post – Pre**			
			Point Estimate[1]	**F-statistic[2]**	**Degrees of freedom[2]**	**P-value[2]**
Perceived Ease of use	Age group	21-35 yrs	0.88	1.76	2.49	0.1823
		36-50 yrs	0.51			
		>50 yrs	0.35			
	Gender	Female	0.63	0.15	1.50	0.6974
		Male	0.72			
	Qualification	BSc/Hons	0.98	2.59	1.50	0.1141
		Non-BSc	0.56			
	Teaching Experience	1-5	0.88	1.30	3.48	0.2867
		6-10	0.72			
		11-20	0.62			
		>21	0.15			
	School Location	Rural	0.59	0.28	2.49	0.7554
		Township	0.68			
		Urban	0.81			
	School Quintile	1-3	0.60	1.04	1.50	0.3136
		4-5	0.87			

[1]Point estimate of the mean difference “post-Pre”.

[2]Overall F-test, degrees of freedom and P-value for the null-hypothesis that the effect of the demographic factor in question on the post-pre difference is zero.

Appendix 15, Table 3: Analysis of perceived behavioural control covariance (ANCOVA) of post-pre differences with regard to biographic factors (n=53)

Dependent Variable	Demographic factor	Factor level	Mean difference: Post – Pre			
			Point Estimate[1]	F-statistic[2]	Degrees of freedom[2]	P-value[2]
Perceived Behavioural Control	Age group	21-35 yrs	0.06	1.03	2.49	0.3629
		36-50 yrs	-0.23			
		>50 yrs	0.18			
	Gender	Female	-0.06	0.08	1.50	0.7850
		Male	0.001			
	Qualification	BSc/Hons	0.20	1.74	1.50	0.1929
		Non-BSc	-0.12			
	Teaching Experience	1-5	-0.05	0.02	3.48	0.9972
		6-10	0.06			
		11-20	-0.01			
		>21	0.01			
	School Location	Rural	-0.17	0.67	2.49	0.5164
		Township	0.06			
		Urban	0.10			
	School Quintile	1-3	-0.08	0.50	1.50	0.4846
		4-5	0.10			

[1]Point estimate of the mean difference “post-Pre”.

[2]Overall F-test, degrees of freedom and P-value for the null-hypothesis that the effect of the demographic factor in question on the post-pre difference is zero.

Appendix 15, Table 4: Analysis of subjective norm covariance (ANCOVA) of post-pre differences with regard to biographic factors (n=53)

Dependent Variable	**Demographic factor**	**Factor level**	**Mean difference: Post – Pre**			
			Point Estimate[1]	**F-statistic[2]**	**Degrees of freedom[2]**	**P-value[2]**
Subjective Norm	Age group	21-35 yrs	-0.19	0.92	2.49	0.4040
		36-50 yrs	-0.4			
		>50 yrs	0.12			
	Gender	Female	-0.19	0.10	1.50	0.7567
		Male	-0.27			
	Qualification	BSc/Hons	0.07	2.08	1.50	0.1556
		Non-BSc	-0.33			
	Teaching Experience	1-5	-0.40	1.69	3.48	0.1816
		6-10	0.29			
		11-20	-0.40			
		>21	-0.25			
	School Location	Rural	-0.22	0.57	2.49	0.5682
		Township	-0.39			
		Urban	-0.03			
	School Quintile	1-3	-0.20	0.10	1.50	0.7584
		4-5	-0.29			

[1]Point estimate of the mean difference “post-Pre”.

[2]Overall F-test, degrees of freedom and P-value for the null-hypothesis that the effect of the demographic factor in question on the post-pre difference is zero.

Appendix 15, Table 5: Analysis of usage covariance (ANCOVA) of post-pre differences with regard to biographic factors (n=53)

Dependent Variable	**Demographic factor**	**Factor level**	**Mean difference: Post – Pre**			
			Point Estimate[1]	**F-statistic[2]**	**Degrees of freedom[2]**	**P-value[2]**
Usage	Age group	21-35 yrs	0.47	0.90	2.49	0.4148
		36-50 yrs	0.29			
		>50 yrs	0.56			
	Gender	Female	0.46	0.51	1.50	0.4782
		Male	0.35			
	Qualification	BSc/Hons	0.65	3.91	1.50	0.0535
		Non-BSc	0.32			
	Teaching Experience	1-5	0.41	0.1	3.48	0.9719
		6-10	0.39			
		11-20	0.46			
		>21	0.34			
	School Location	Rural	0.25	1.89	2.49	0.1620
		Township	0.49			
		Urban	0.59			
	School Quintile	1-3	0.38	0.42	1.50	0.5217
		4-5	0.49			

[1]Point estimate of the mean difference “post-Pre”.

[2]Overall F-test, degrees of freedom and P-value for the null-hypothesis that the effect of the demographic factor in question on the post-pre difference is zero.

APPENDIX 16 PEDAGOGICAL CONTENT KNOWLEDGE (PCK), CHAN, ROLLNICK, & GESS-NEWSOME (2019)

PCK component: Knowledge and skills related to:	**Explanation** Observed through observing:	**Questions to help you develop this PCK component**
Curricular saliency	Accuracy and coherence of content; Selection and appropriate sequencing of big ideas; Alignment to curriculum objectives	• What do the learners in this grade need to learn about ___, according to the curriculum? • What concepts are key to understanding ____, and in what sequence should they be taught to make the most sense to learners?
Conceptual topic-specific teaching strategies	Selection and use of appropriate teaching strategies, such as use of representations and analogies	• How can I represent ____ and its components in a clear way, appropriate for my learners? • What could I compare parts of ____ to, to improve the learners' understanding?
Student understanding	Awareness of possible misconceptions and difficulties and how to address these	• What might be difficult for the learners to understand about ____ or about the representations and analogies I use, and how can I help the learners with these difficulties?
Integration between components	Promotion of interaction and use of this to monitor and adjust teaching to match learner needs	• How can I get the learners mentally engaged? • How can I get the learners to speak about their understanding and how will I adjust my teaching according to what they say?
Pedagogical reasoning	Explanation of why specific actions were performed in the lesson	• How will I justify the things I do in the class, in terms of my understanding of what helps learners learn better?

ETHICS STATEMENT

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
EDUCATION
OPVOEDKUNDE

Faculty of Education

22-Nov-2017

Dear **Mrs Molie Mafojane**

Ethics Clearance: **Promoting teachers' usage of information and communication technologies in some selected South African schools.**

Principal Investigator: **Mrs Molie Mafojane**

Department: **School of Education Studies (Bloemfontein Campus)**

APPLICATION APPROVED

With reference to you application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2017/1134**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours faithfully

Prof. MM Mokhele
Chairperson: Ethics Committee

Education Ethics Committee
Office of the Dean: Education
T: +27 (0)51 401 9683| F: +27 (0)86 546 1113 | E: NkoaneMM@ufs.ac.za
Winkie Direko Building | P.O. Box/Posbus 339 | Bloemfontein 9300 | South Africa
www.ufs.ac.za

PROOF OF LANGUAGE EDITING

To whom it may concern

This is to state that the Ph.D. by Molie Abittah Johanna Mafojane titled *Changing Perceptions Regarding The Use Of Information And Communication Technologies Through Subject Specific Professional Development: Insights From A South African Case Study* has been language edited by me, according to the tenets of academic discourse. The final responsibility to implement any suggested language changes resides with the student.

Annamarie du Preez

B.Bibl.; B.A. Hons. (English)
07-11-2021