Selection and use of mobile educational applications that support inquiry-based science teaching

by

Marelet Moolman

SELECTION AND USE OF MOBILE EDUCATIONAL APPLICATIONS THAT SUPPORT INQUIRY-BASED SCIENCE TEACHING

by

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Dissertation

submitted in partial fulfilment of the requirements for the degree of

MAGISTER EDUCATIONIS

in

SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION

at the

SCHOOL OF SCIENCE, MATHEMATICS AND TECHNOLOGY IN EDUCATION

of the

UNIVERSITY OF PRETORIA

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DECLARATION

I, Marelet A. Moolman, hereby declare that this document: "*Selection and use of mobile educational applications that support inquiry-based Science teaching"*, which I have submitted for the M.Ed in Science, Mathematics and Technology degree at the University of Pretoria, is my own original work and that it has not previously been submitted to any other institution. All sources used or quoted in this document are indicated and acknowledged by means of a comprehensive list of references.

M.A. Moolman

ABSTRACT

A 21st century learner should be encouraged to analyse data, apply knowledge and be creative; all this can only be accomplished when the method of instruction changes according to McCoog (2008). As stated by Cramer (2007) one of the vital characteristics of a 21st century educator is the ability to select resources in an unbounded developmental setting. The correct selection of resources would surely be able to contribute to successful teaching and learning (Pienaar, 2008). This research reflects on the process educators employ to select the appropriate mobile educational applications to support inquiry-based science teaching as part of the information communication for rural education development project.

Despite the apparent need to adapt our teaching to provide for a 21st century learner, educators receive arguably little or no guidance to select mobile educational resources (applications) for a specific educational environment. The necessity for the educator to adapt and gain skills to address 21st century learners is also supported by the fact that inquiry-based science teaching relies heavily on resources (Lin, Hong, Yang & Lee, 2012).

The selection process and use of apps are explored and contextualised by the results using the TPACK-framework. Three case studies were conducted to compare how three educators from three different schools select and use apps to enhance inquiry-based science teaching. A qualitative collective case study were conducted by means of conducting an interview, an observation and a questionnaire.

The main research question asked was: How do the selection and use of mobile educational applications support inquiry-based teaching in Physical Science in the FET phase?

The research provided a set of proposed guidelines to select applications that could also support inquiry-based science teaching in the further education and training phase in South Africa.

The guidelines were developed to guide and aid science educators in selecting the appropriate applications for science lessons. The research links these guidelines with the characteristics of inquiry-based teaching and how apps could be used to support this teaching style.

Key words: *applications, guidelines to select applications, inquiry-based teaching, science education, selecting resources, South African education.*

DEDICATION

I dedicate this study to my best friend and husband Zach Moolman, who has always motivated and supported me, always cheering me on and continuously inspiring me to be better than today.

My father Alwyn Lindholm, who inspired me to study science, maths and technology, opening many doors for my future while constantly valuing academic performance and improvement.

ACKNOWLEDGEMENTS

This work acknowledges the TECH4RED project and more specifically the ICT4RED component, for the bursary provided for my studies, and also for the opportunity to link my research to the project. The Cofimvaba Technology for Rural Education Development (TECH4RED) project was a joint initiative between the Department of Science and Technology (DST), the Department of Basic Education (DBE) and the Eastern Cape Department of Education (ECDOE) and was aimed at contributing to the improvement of rural education through technology-led innovation. The Department of Rural Development and Land Reform (DRDLR) also joined as a key partner in the initiative in 2013. ICT4RED focused on the ICT aspects of the initiative and investigated how the application and deployment of new and existing technologies (which include e-textbooks, tablets and other supporting technologies) at schools in the Cofimvaba district of the Eastern Cape Province could assist to develop a framework, which can be replicated and scaled to other provinces and across the rural education system.

The writing of my master's dissertation has been a challenge and without the support, enthusiasm and direction of the following people, I would not have completed this study. I owe them my sincere appreciation and I wish to thank them.

- My research supervisor, Dr Ronel Callaghan, for her instantaneous feedback, enthusiasm, patience and tremendous time, guidance and advice despite other obligations. Her numerous back-and-forth brainstorm sessions were joined with coffee and treats as 'inspiration'.
- My co-supervisor, Professor Marlien Herselman, for your inspiration, enthusiasm and time, despite your own commitments. Your knowledge and your willingness to share with me motivated and continue to inspire me.
- My co-supervisor, Ms Corene Coetzee, who listened to all my preliminary ideas, directing me to the correct project and supervisors, while always providing valuable feedback especially regarding the teaching principles of science education in South Africa.
- Professor Willem Frazer, for proof-reading and directing my studies in the initial stages.
- To all the participants, your time was valued and appreciated.
- To my fellow post-graduate colleague Candice Langenhoven, who became a friend and sounding board.

- Charles and Una Moolman, my in-laws, who strengthened me through their prayers and encouragement.
- To all my dear friends and family for your continual support and encouragement.

Above all, to Jesus Christ, only through Your grace.

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ABBREVIATIONS

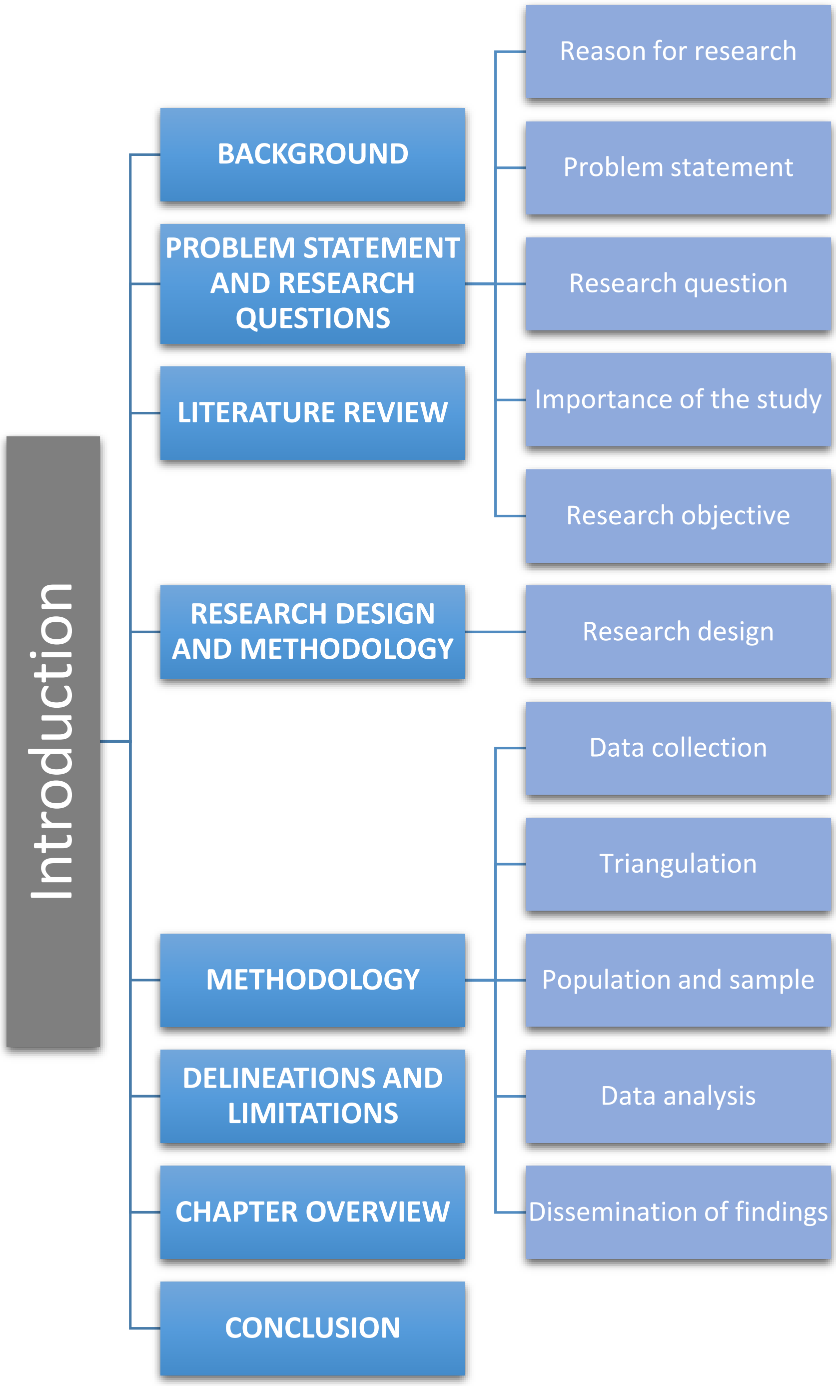
ANA	Annual National Assessment
App	Application
CSIR	Council for Scientific and Industrial Research
DBE	Department of Basic Education
ICT	Information and Communication Technology
IEB	Independent Examinations Board
IQ	Inquiry-based
FET	Further Education and Training
NRI	Networked Readiness Index
Tech4RED	Technology for Rural Education
ICT4RED	Information and Communication Technology for Rural Education Development
TPACK	Technological Pedagogical Content Knowledge
UX	User Experience
Wi-Fi	Wireless Fidelity

LIST OF CONCEPTS

E-learning	Electronic learning and teaching
M-learning	Mobile learning and teaching

1. CHAPTER 1: INTRODUCTION

Map of Chapter 1: INTRODUCTION



1.1 BACKGROUND

Only a few years ago schooling essentially meant making use of the "three-Rs system"; Reading, (w)Riting and (a)Rithmetic, but according to McCoog (2008), today the "three Rs" for the 21st century refer to 'Rigor, Relevance and Real-world skills'. This poses a challenge for educators all over the world, because our education system fails to provide these skills, rather focusing on memorizing knowledge (Tucci, 2009). McCoog (2008) suggests that education must aim to teach students in a manner that utilises the skills they already possess. Emphasis on what students are capable to do with knowledge rather than what element of knowledge they have memorised is the key essence of these so called 21st century skills (Silva, 2008).

A 21st century learner should be encouraged to analyse data, apply knowledge and be creative; all this can only be accomplished when the method of instruction changes (McCoog, 2008). Consequently to effectively make changes to the schooling system, the unique challenges and opportunities facing each school must be carefully considered (Tucci, 2009); however, according to technologist Marc Prensky (as cited by McCoog, 2008) technology can assist 21st century teaching due to its exciting and engaging manner, which in turn makes a meaningful contribution to skills in the marketplace. According to ITU (2011) technology users have increased rapidly during the last couple of years. It can be argued that a remarkable increase in internet users is being seen worldwide and it is estimated that 45% of internet users are below the age of twenty-five (ITU, 2011).

It is easy to omit developing countries from data presented about technological development, but in the developing world 79% of the population had mobile-cellular/phone subscriptions by 2011 (ITU, 2011; Phillips, Lyons, Page, Viviez, Molina & Ensor, 2011). It is therefore argued that information and communication technology (ICT) is the world's fastest growing information distribution platform and poses major development opportunities (Phillips *et al*., 2011).

ICT is one of the strategies claiming to benefit education (Kozma, 2005) and in South Africa the Department of Basic Education (DBE) has set out thirteen steps to improve education and went on to call the action plan 'Schooling 2025' (DBE, 2012). We can therefore argue that there is a definite need for South Africa to keep up with the technologically advanced world and use the ICT platform to connect schools, increase school enrolment rates and prepare learners for careers later in life (Siqueira, Braz & Melo, 2007). However, although ICT is an excellent tool that can transform schools as mentioned above, according to Currie and Kilfoye (2010), it cannot function on its own. Many ICT plans have failed in the past because the focus was on the technological tools and appliance alone, and we must therefore aim to look at users and assist them to make the transition from a theoretical to a practical curriculum (Van Rensburg, Veldsman & Jenkins, 2008).

It is also argued that ICT cannot be the sole focus; only with the aid of equipped teachers, the correct resources and willing students can ICT flourish in education (Van Rensburg *et al*., 2008). A school's 'resource package' which consists of the educators' ability, physical equipment and curriculum-supporting resource material, can either promote or hinder instruction and thus influence the students' motivation and educational attainment (Blount & McNeill, 2011; Rolando, Salvador & Luz, 2013). The aim must therefore be to look at ICT as a holistic tool, including the users, their experience, resources and training along with the abovementioned 'school's resource package' (Jimenez-Castellanos, 2010; Rolando *et al*., 2013). This brings us to the problem of how ICT should be employed to support scholars' understanding of the subject material?

1.2 PROBLEM STATEMENT AND RESEARCH QUESTIONS

1.2.1 Reason for research

Teaching is described by Mason (2009) as the connection between content and the learners' understanding of the presented material, a form of ordered inquiry into the human understanding. McColskey and O'Sullivan (2000) supports this statement and goes on to say that education is a complex structure between two systems; one being the interaction between the learner and relevant resources and the second being the knowledge about instructive processes held by the educator. To ensure the new content is presented to learners effectively, ICT can be an excellent support tool for the transition to a practical curriculum when applied appropriately (Blount & McNeill, 2011; Grossman, Hammerness & McDonald, 2009).

It is argued that ICT can support and foster learning by expanding learning opportunities and motivating students (Rolando *et al*., 2013). Osborne and Hennessy (2003) state that this is even more valid for ICT in science education, where ICT can assist in developing critical thinking skills, handling and collecting data and presenting knowledge in a visual manner to increase student engagement and motivation.

It is suggested by Pardales and Girod (2006) that to teach science effectively these above-mentioned skills should be addressed in every task and as stated by Evans (2012) one of the most vital points to ensure effective learning is the ability to select the correct tools for the right task, additionally Rolando *et al*. (2013) go on to argue that ICT could be used to bridge this gap. Pardales and Girod (2006) argue that science teaching must aim to be a process where understanding is obtained by means of a clear reasoning or scientific method of thought. It can therefore be argued that inquiry teaching is one teaching strategy that could support the teaching of science, due to its probing approach (Minner, Levy & Century, 2010; Academy of Science of South Africa, 2010). It is argued by Lin, Hong, Yang and Lee (2012) that ICT could support inquiry-based teaching by offering curricular resources and materials rather than a traditional approach. According to Harlen and Allende (2009) the fundamental principles of inquiry-based teaching are "...to develop understanding about the scientific aspects of the world around you through the development and use of inquiry skills".

Some authors state that there is a need to re-conceptualise education in South Africa to address the above-mentioned issues of teaching an ICT-driven generation and the need to teach science in a manner that is comprehensible and appealing to ensure better enrolment and results (Sharples, Taylor & Vavoula, 2005; Karakas, 2009; Siqueira *et al*., 2007). As mentioned before the issue is to look at all factors involving ICT's role in education to ensure success (Van Rensburg *et al*., 2008) and as stated by Jimenez-Castellanos (2010) the selected resources could promote or hinder quality education, thus influencing the overall achievement of the student.

It is also suggested that one of the greatest expectations for the use of ICT is to enhance education through improved delivery and improved materials (Kumar & Altschuld, 1999). However, since the start of the ICT-generation, educators have been bombarded with the initiative to develop 21st century learners, especially in science, while few teachers are equipped with 21st century skills in manipulating technologically advanced teaching tools and material or provided with the actual technological tools needed to achieve this goal (Currie & Kilfoye, 2010).

Cramer (2007) proposes that educators will have to reconsider what learning looks like, conclude what the role of the educator is and determine how resources can support effective learning to take place. A critical part of 21st century teaching is the skill to select resources that would enhance effective learning (Cramer, 2007).

1.2.2 Problem statement

It is argued that the lack of teaching materials and other resources is often used to justify why in many cases the teacher is the learners' only available resource (Ottevanger, Van den Akker & De Feiter, 2007). However, various studies have been conducted on the impact of ICT in education and the teachers' perception of these tools (Law, Lee & Chan, 2010; Martinovic & Zhang, 2012) only to find that seemingly most educators were not aware of the endless opportunities these tools provide and that educators were seldom using technology already available to them to enhance their teaching (Rolando *et al*., 2013).

As stated by Cheung and Slavin (2013) the question is not whether or not teachers should be using technology, but rather when they implement ICT, 'how can they use it effectively'? The focal point in all schools wanting to increase effective technological use of such ICT resources should be on making use of innovative and enhanced tools to properly harness the power of ICT in education (Cheung & Slavin, 2013). Learners need to be able to move between mobile devices, computer, books and notepads (Sharples *et al.*, 2005). Teachers are the driving force behind any change in education and according to Mishra and Koehler (2006) the success of ICT integration in classrooms depends mainly on the ability of teachers to manipulate teaching environments and effect change. According to the DBE's action plan, 'Schooling 2025', the focus will shift from only using traditional material and methods in order to teach to effective implementation of technology to effectively addressing some of the issues in education in South Africa (DBE, 2012).

The Department of Science and Technology (DST) and the Department of Basic Education (DBE) has therefore identified numerous challenges faced by educational institutions in rural areas and joined forces with the CSIR and other national System of Innovation (SOI) partners to design the Tech4RED program (Ford, 2012). The aim of this project is to find effective ways to ease poverty and inequality through research and living labs (Ford, 2012). We can therefore conclude that South African educational management bodies are moving in the right direction in terms of an ICT strategy; however, we also know that technology transforms how people think, work, research, collaborate and communicate (Redpath, 2012) and therefore we still face the challenge of equipping educators to embrace the changes and opportunities available through ICT and have them take part in proper training in order to effectively implement the new technological strategy (Ford, 2012).

As mentioned above the problem is to address how educators can implement ICT but for the current contribution and study we focus only on the possibilities of mobile resources and the educational mobile applications used in particular. As stated by Stead (2004) mobile resources (or devices) can be a good 'bridge into ICT', where scholars and educators can gain confidence in the tools and their own skills.

Despite the apparent need to adapt our teaching to provide for a mobile or ICT-generation, educators receive arguably little or no guidance to select mobile educational resources (applications) for a specific educational environment. As stated by Cramer (2007) one of the vital characteristics of a 21st century educator is the ability to select resources in an unbounded developmental setting. The necessity for the educator to adapt and gain skills to address 21st century learners is also supported by the fact that inquiry-based teaching relies heavily on resources (Lin *et al*., 2012). Pienaar (2008) states that the correct selection of resources would surely be able to contribute to successful teaching and learning.

1.2.3 Research question

In the light of the former discussion, the key research question therefore is:

How do the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?

The following sub-questions would assist in answering the main research question:

SQ1. What determines the preferred selection or specific mobile educational applications for science teachers?

SQ2. How can the use of these mobile educational applications support inquiry-based teaching?

SQ3. How can mobile educational applications support inquiry-based teaching in science in a rural and urban context in South Africa?

1.2.4 Research objective

This study aimed to investigate the selection process followed by educators in selecting applications (apps) that could support science teaching in the FET phase with the help of inquiry-based teaching. The researcher identified, in conclusion, a set of proposed guidelines that could be used in the future by educators as an indication to successfully select apps for effective FET inquiry-based science teaching.

To achieve the research objective (identified guidelines) as mentioned above, the research was divided into five outcomes to assist the researcher to reach the objective as set out by figure 1-1 below:

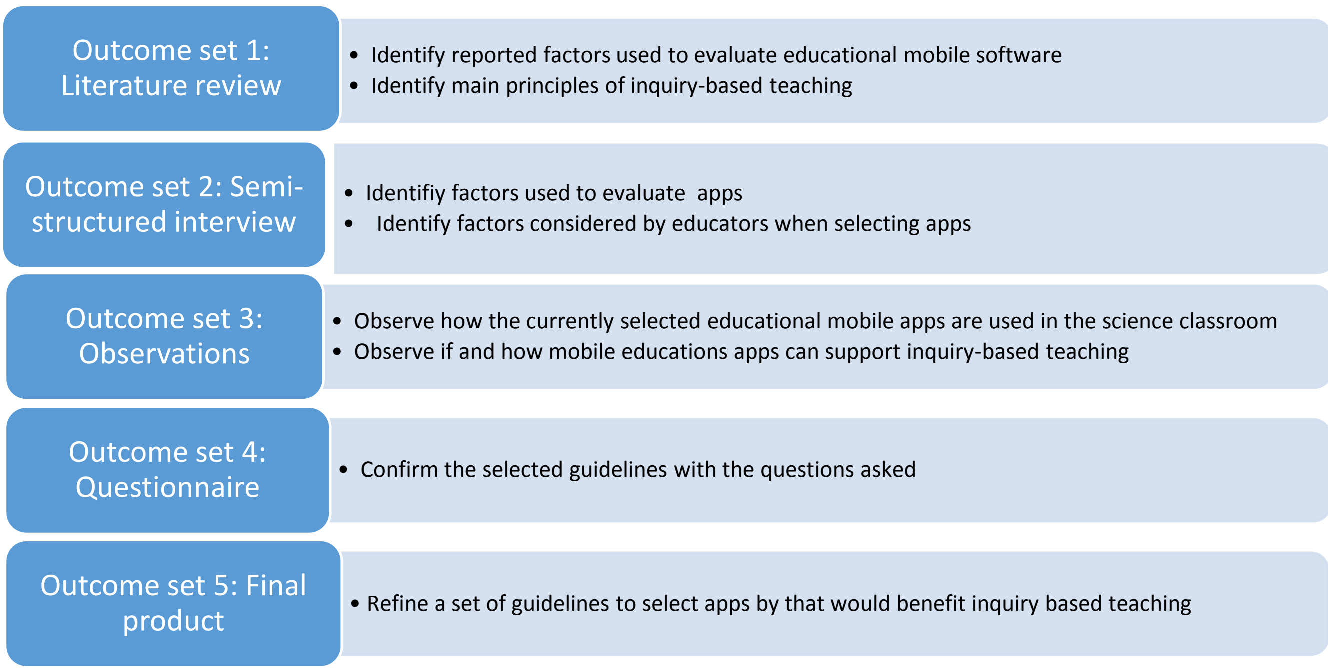


FIGURE 1-1: Research objective plan (source: The Researcher)

As seen above in figure 1-1 the objective or final 'product' that the research seeks to develop by means of this study was a set of guidelines to assist educators in selecting mobile educational resources or apps for science education. The research started with the literature review to identify possible guidelines used to evaluate resources and software. The principles for inquiry-based teaching were investigated through the literature review. These factors and principles were used to design the research instruments used in the study. The next step was the use of semi-structured interviews to identify guidelines suggested by educators. Thirdly, classroom observations were conducted, followed by a questionnaire. The aim of the questionnaire was to validate the proposed factors and lastly to define the data collected and propose a set of guidelines to select apps to support inquiry-based teaching. A more in detail explanation of the process to reach the objective of the study is set out later in chapter 3, during the research design and methodology discussion.

1.2.5 Importance of the study

The major socio-economic developmental challenges that are faced by most sub-Saharan Africa countries are economic diversity, poverty, unemployment, disease and the unsustainable use of natural resources (Glewwe, Hanushek, Humpage & Ravina, 2011; Van der Berg, 2008). According to Van der Berg (2008) providing better education to citizens has been shown to be one of the ways to effectively alleviate poverty.

As pointed out by Beard, Dale and Hutchins (2007), it is only when educators gain skills to properly implement ICT that they will use technology as a tool and integral part of the teaching process, only then can they teach with confidence to design and demonstrate ICT as part of their subject framework.

It is argued that education has to be transformed in an attempt to address the above-mentioned issues (Beard *et al*., 2007; Cheung & Slavin, 2013) and technology arguably proves to be an unavoidable tool in the attempt to educate the current ICT-generation (Karakas, 2009). According to Cheung and Slavin (2013) most newly-qualified educators are more technologically skilled and ready to employ educational technology in their teaching. The same author continues to say that apps are now more reasonably priced, with some apps being available free of charge (Cheung & Slavin, 2013); however, very little information is available to guide educators in selecting valuable apps for inquiry-based teaching styles (Pienaar, 2008).

Research has been done on selecting the correct resources to support effective learning (McColskey & O'Sullivan, 2000; McCoog, 2008; Currie & Kilfoye, 2010 & Crawford, 2007); however, very little research has been done on educational apps, especially in South Africa, with vague or no guidelines available in the selection of apps to support an inquiry-based science curriculum. The study hopes to develop a set of guidelines that could be utilised by educators when selecting apps and also by educational resource developers when designing these apps.

1.3 LITERATURE REVIEW

A brief overview of the literature review is presented below. The concepts explored here are expanded in chapter 2.

1.3.1 Education in the 21st century

Education is a complex structure of human relationships between the learner and the educator, the learner and their exposure, the learner and relevant resources, the educator and knowledge of the instructive processes (McColskey & O'Sullivan, 2000; Crawford, 2007). Veen (2006) states that today's students belong to a 'computer based' (ICT) generation. According to Prensky (as cited by Veen, 2006) the ICT-generation is a group of individuals who can multi-task, will analyse icons before text, are always connected via technology, prefer to work together in teams and learn by searching for, playing with and externalising information. As explained by Crawford (2007); Higgins (2014) and Johnson (2015), due to the vast changes that have taken place in socio-cultural, economic and technological fields we can only adapt our teaching styles and resources to fit a new generation of learners, a technological advanced generation as explained by Veen (2006). Nonetheless it is argued that technological development is happening faster than ever before and technology is referred to as a fundamental human structure needed to secure a desirable job in modern times (Wagner, 2000; Coulter, 2010 & Redish, n.d.).

1.3.2 Selecting resources for the 21st century

The correct resource combination may also be important; it is argued that without sufficient combinations of textbooks and other classroom resources, teachers cannot improve their quality of teaching (Van der Berg, 2008). Diamond (2012) argues that optimal learning involves individuals interacting and responding successfully to information and learning situations, however according to Veen (2006) the ICT-generation showed different behaviour patterns in dealing with information and communication. Therefore it can be suggested that when considering new technological resources these factors might be vital in addressing the effective training of the future workforce through education.

When keeping in mind our vast array of academic environments, economic culture and educational limitations, one might question the type of resources South African institutions choose for our learners and start looking into the adaptability of international material to our specific needs and economic situation (Modisaotsile, 2012). Electronic learning has been a topic growing in popularity in education recently where e-learning refers to the use of any electronic media, information and communication technologies (ICT) in education (Mishra, Zhao & Tan, 2000 & Alonso, Lopez, Manrique & Vines, 2005). Santoro and Bishop (2010), state that computerised materials are classified as assisting tools of instruction when they include intended learning goals; instructional strategies and consist of learning materials and activities that could include assessments as well.

Apps are a “lighter” version of computer software applications meant for any mobile device like a mobile phone, tablet or portable media player (Rishi, 2012).

1.3.3 Education in South Africa

Education research has consistently found that learners’ socio-economic status plays an important role in the outcomes achieved through education (Van der Berg, 2008). Teaching can be a decisive tool to address the issues Africa faces daily when used correctly, therefore Van der Berg (2008) suggests that one of the advantages that education provides could be to improve the living standard of communities and contribute to the social and economic development of countries, . Research shows that only half of the learners enrolled in primary schools in South Africa currently make it to Grade 12; the majority of learners who then pass Grade 12 do not meet the minimum requirements for university entrance (Modisaotsile, 2012). We can therefore conclude that South Africa is facing a major crisis in education (Van der Berg (2008), Louw & Du Toit, 2007, Van der Merwe & Sloman (2014)).

According to Zawilinski (2009) learning takes place not in isolation and various factors will have an effect on learners’ learning experience and process; for example the type of school attended, the resources used, instructional approaches, teacher characteristics, students attitudes, and home support. When it is seemingly impracticable to instantly enhance the home circumstances of thousands of learners in a certain educational setting in an effort to ensure better education, we can aim to address other circumstances to gradually improve educational outcomes (Van der Berg, 2008). When a student studies in a ‘study-orientated’ environment it is argued by Van der Berg (2008) that it may very well lead to better grades and in turn help create better circumstances.

1.3.4 Teaching styles for the 21st century learner

It is argued that, in all educational environments, the educators' teaching styles should also keep up with the rapid changes occurring daily and teaching styles should be shaped to address the audience they are presented to (Visser-Wijnveen, Stes & Van Petegem, 2014; Salpeter, 2008; Sherifat, 2014). According to Shepherd, McCunnis, Brown and Hair (2010) and Gibbs (2003) various teaching styles, or a combination, could be used to support one's teaching and can be a selection of: traditional lectures, case method, discussion, active learning, inquiry, co-operative, integrating, technology and distance learning; however the challenge is finding the strategy that best supports your subject and suits the learners involved.

1.3.5 Inquiry-based teaching

'Inquiry' teaching refers to a study of the natural world and drawing explanations from evidence, also called an 'active process' (Anderson, 2007 & Taylor 2015). Minner *et al*. (2010) define inquiry-based learning as a fragmentary process where individuals find meaning through the selective gathering of information and the effective integration or replacement of existing knowledge. According to Anderson (2007), there are four elements that attempt to explain inquiry-based teaching; namely:

- individuals should be actively constructing and finding meaning for themselves;
- an individual's prior conceptions may need to be modified before meaning can be found;
- the individual's understandings are dependent on the context in which the meanings are drawn; and
- meaning is effected by the society.

The thought process are broken down into four steps according to Minner *et al*. (2010) and Handelsman, Egbert-May, Beichner, Bruns, Chang, DeHaan, Gentile, Lauffer, Stewart, Tilghman and Wood (2004), where learners should be engaged by questions and constructively valuating and formulating explanations based on evidence and lastly they would compare their own explanations on alternative explanations.

1.3.6 Resources to support inquiry-based teaching

The right selection of resources would ensure that the correct message is transferred across to the right audience using the best available tools (Chadwick, 2012 & Abd-El-Khalick, BouJaoude, Duschl, Lederman, Mamlok-Naaman & Hofstein, 2004). Inquiry-based teaching is a method of inquisition to observe the world and propose explanations of what is happening around us (Anderson, 2007; Arce, Bodner & Hutchinson, 2014) and educational software should be selected to support this fundamental principle in science. Educators should therefore be trained to filter and operate educational resources in such a manner that it is not hindering their teaching of the subject but rather supporting the inquiry-based nature that highlight all science orientated subjects (Crawford, 2007).

1.4. RESEARCH METHODOLOGY

The research methodology is summarised below, but expanded in the research design and methodology chapter (*cf*. Chapter 3).

1.4.1 Research design

In this study, a qualitative research design with a case study strategy was used (*cf.* Section 3.3).

The model illustrated below in figure 1-2 has been adapted from Saunders, Lewis and Thornhill (2015), referred to as the 'research onion', consisting of various layers that represent the different aspects of the research and a clear explanation of their perspectives.

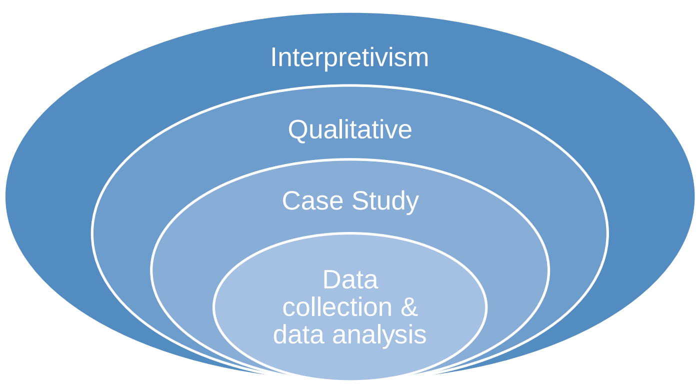


FIGURE 1-2: The adapted research onion (adapted from: Saunders, Lewis & Thornhill, 2015)

The 'research onion', as illustrated in figure 1-2 above, is used to explain each 'layer' of this study emerging from the abstract to the concrete layer of data collection and analyses (Saunders *et al.,* 2000).

1.4.2 Interpretivism: philosophy of paradigm

Morgan (1980) states that a paradigm is any worldview that would include different schools of thought or perspectives but similar fundamental assumptions about the nature of the reality that they address. This study aimed to search for an understanding through investigating people in their natural environment (Kelliher, 2005), therefore in this investigation the educators were observed in their everyday classrooms (*cf.* Section 3.3.1). As stated by Kaplan and Maxwell (1994) one understands better by investigating the complexity of human understanding with the help of social constructions such as explanations, documents, and awareness and shared meanings.

Due to the nature of the study an interpretative paradigm was used to investigate teachers' preference of the apps they use. The study aimed to make an in-depth enquiry regarding the selected teachers' understanding and views of their pupils' learning with the use of applications, however one would not be able to quantify the teachers' understanding and therefore the interpretative paradigm would be best suited to this study (Morgan, 1980).

1.4.3 Qualitative research: approach to the research

Becker (1996) describes three major differences between qualitative and quantitative research: the purpose of interrogation to draw conclusions on explanations and understanding, the role of the researcher from personal to impersonal participant; and knowledge as constructed information versus discovered information. During qualitative research a hypothesis is not needed to conduct an investigation, as it aims to provide better understanding of the interaction between systems (Saunders *et al.,* 2000). Some of the main differences between qualitative and quantitative research are presented in chapter 3 (*cf*. Section 3.3.2) as well as a motivation for choosing a qualitative research design (*cf.* Section 3.3.3).

This study is an enquiry into human learning and the use of apps as an effective resource in facilitating optimum education. For the purpose of this study, the researcher felt that qualitative research would enhance the possibility for some kind of objectivity which would have been lost if any other method had been applied (Ponterotto, 2006).

The research approach is therefore qualitative rather than a quantitative approach; due to the aim to clarify the multiple realities presented in the data and would best suit an interpretivist research philosophy (Maree, 2007).

1.4.4 Case study: strategy of the research

A case study is clarified by Bromley (1991) and Yin (1994) as a systematic approach to explaining and understanding a phenomenon, interest or event. This researcher observed three educators in their everyday milieu and investigated how they use resources to enhance their teaching; therefore each teacher was viewed as an individual case study. The criteria used to select the cases are presented and discussed in chapter 3 (*cf*. Section 3.6).

There are six steps proposed by Stake (2005) for conducting case study research as seen below and discussed in chapter 3 (*cf*. Section 3.3.4):

1. Determine and define the research question
2. Select the case and determine the data gathering and analysis techniques
3. Prepare to collect the data
4. Collect data in the field
5. Evaluate and analyse the data
6. Prepare reports

These steps proposed by Stake (2005) are discussed as part of the research process below.

1.4.5 Research process

The research process is illustrated in figure 1-3 below and discussed in more detail in chapter 3 (*cf.* Section 3.4).

FIGURE 1-3: Research process (source: Maree, 2007; Gelo, Burns & Bush, 2008)

The research process as illustrated above in figure 1-3 involves a continuous interaction between the data collected and the gaps identifying in the data; as well as a link between the researcher reflecting on the collected data and the plans for further investigation. To ensure that the objective or outcomes of the study are ultimately reached (*cf*. Figure 1-1), a step-by-step research process plan was used, as illustrated in figure 1-4 below:

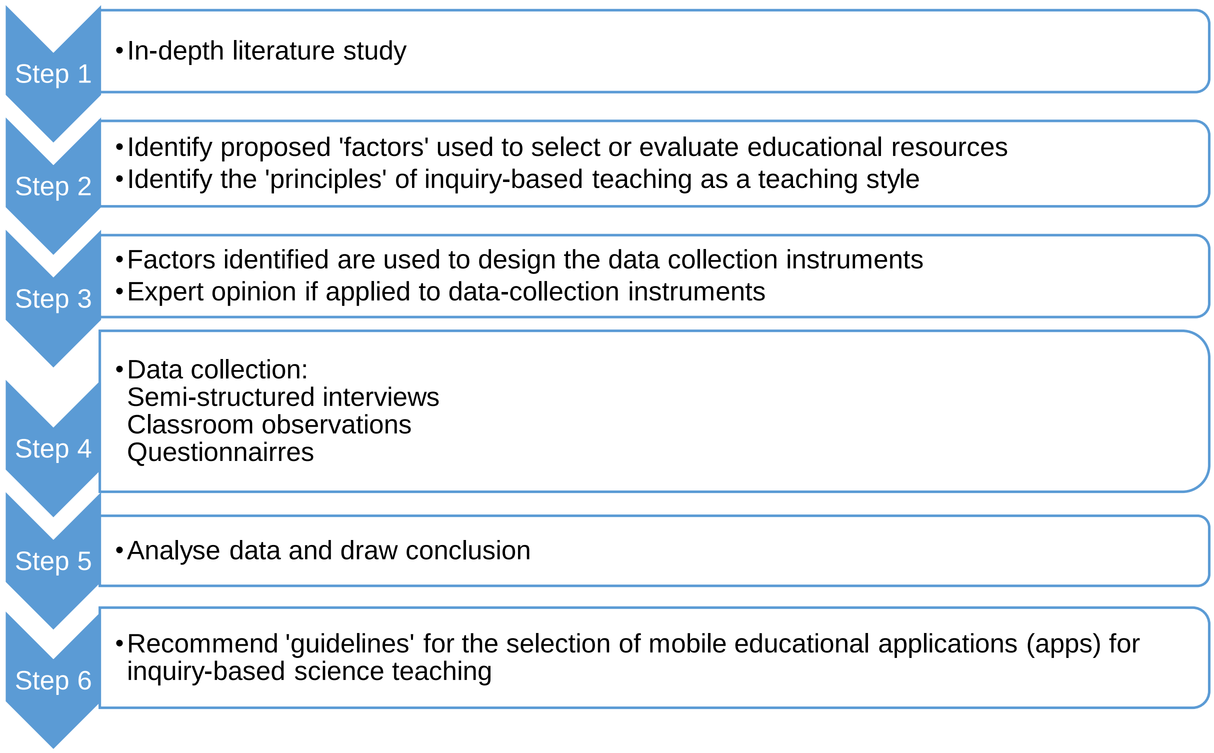


FIGURE 1-4: Step-by-step research process (source: The Researcher)

The research steps that were followed are set out above in figure 1-4 and elaborated in chapter 3 (*cf*. Section 3.4).

1.4.6 Intervention and participant activities

No interventions were required during this research. Participants were asked to participate in interviews, classroom observation and questionnaires. The researcher's aim was to search for guidelines educators employ when selecting resources and an understanding of how these selected applications are utilised in science teaching. The principles of inquiry-based teaching were then compared with the implantation of these applications in the science classroom. The researcher used the afore-mentioned data collection instruments to compile a proposed set of guidelines and used this to verify participants' responses.

1.4.7 Data collection

The selection of data collection instruments depends on the nature and type of research conducted and the methods used to triangulate between sources (Paul, 1996). It is also argued that by using more than one data collection source the interpretations are seen from various points and are more reliable (Maree, 2007). During this study three instruments were used, as seen in table 1-1 below, to seek the guidelines that are used to select apps (*cf*. Section 3.7).

TABLE 1-1: Data collection instruments (source: The researcher)

Data collection technique	Documentation method	Aim
Literature review	Background reading to identify and summarise findings.	Identify possible 'factors' to select educational resources. Identify 'principles' of inquiry-based teaching.
Semi-structured interviews	Audio recording and transcriptions.	Confirm or edit the proposed list of 'factors' used by educators to select apps used in the FET phase science classroom.
Observations	Making field notes and transcriptions.	Observe how educators are using the selected apps. Further edit or confirm proposed 'factors' identified by educators. Identify if any of the 'principles' of inquiry-based teaching are used while teaching science with the help of apps.
Questionnaires	Preconfigured forms filled in by participants.	Confirm or edit the proposed 'factors' identified. Confirm or edit the 'principles' of inquiry-based teaching used in science lessons while using apps. Compare and combine the identified 'factors' and 'principles' to propose a set of guidelines to use when selecting apps for a FET science classroom.

As seen above in table 1-1 various data-collection instruments were used to conduct the research. Each instrument is explained in more detail below.

1.4.7.1 Semi-structured interviews

Semi-structured interviews allow for 'probing', a process where the researchers verify their understanding of the presented data (Qu & Dumay, 2011; Driskell, Blickensderfer & Salas, 2013).

Semi-structured interviews preceded the classroom observations that took place during this study. Teachers were interviewed on and probed as fully explained in chapter 3 (*cf.* Section 3.7.2) regarding the selection process of mobile educational resources they use in class. The process of how the questionnaires were designed to accommodate all the components of the TPACK framework is also explained in chapter 3 (cf. Section 3.7.2; Figure 3-8 & Table 3-8).

1.4.7.2 Observations

The observations took place in an overt fashion, a method where the educator is informed about the observations and may request access to the recordings afterwards (Boote & Mathews, 1999). It is argued by Blanton, Sindelar and Correa (2006) that natural observations rather than contrived observations would support interpretative studies best, therefore the researcher observed the three selected educators in their classrooms when utilising apps as part of their science teaching.

Observations were used to make running physical notes as fully described in chapter 3 (*cf*. Section 3.7.3). The manner in which apps are manipulated in lessons were coded and fully described in chapter 3 (*cf.* Section 3.7.3 & Table 3-9).

The observation technique aimed for the researcher to extract detailed, augmented information about how teachers use the chosen apps in their teaching and whether any of these apps could possibly support the principles of inquiry-based teaching as a teaching strategy.

1.4.7.3 Questionnaires

Questionnaires, as explained by Maree (2007) and Richardson (2004), refer to a set of questions and answers provided to the participants. These 'answer-response' questionnaires could be presented in various manners, however for this study the questionnaire was presented after the semi-structured interviews and observations to verify the findings, therefore a scaled-response would be used (*cf*. Section 3.7.4 & Table 3-10).

The questions asked were linked to 'why' and 'how' teachers apply apps in their classrooms. The questionnaire aimed to provide a proposed set of guidelines that teachers' use to select apps for science teaching.

1.5 TRIANGULATION

One of the ultimate goals of a researcher is to design a study that has a strong internal and external validity and reliability, with procedures that would decrease biases within the research (Thurmond, 2001; Jonsen & Jehn, 2009; Bekhet & Zauszniewski, 2012). Two ways to increase the validity, strength and interpretative potential of the study is, as explained by Thurmond (2001), to decrease investigators' biases and use methods involving triangulation. Triangulation refers to the method of using a combination of several research methodologies in one study in order to ensure confident results (Maree, 2007; Tustin, Ligthelm, Martin & Van Wyk, 2005; Bekhet & Zauszniewski, 2012 & Thurmond, 2001).

Triangulation was employed to verify findings from independent measures (*cf*. Table 3-11). To ensure that the test had face validity, the questionnaires were compiled with the assistance of the supervisor and co-supervisors of this project, ensuring that the questions are relevant to the purpose and to ensure the questions are free from uncertainty in their wording. In this way, the aim is to get responses that are properly related to candidates' understanding of the chosen app. Triangulation is explained by Maree (2007) and Stavros and Westberg (2009) as a fundamental technique to validate data through cross-verification from multiple sources. Another advantage of triangulation is the amount of data collected that could be analysed and indicate possible patterns (Thurmond, 2001; Stavros & Westberg, 2009). Various types of triangulation are proposed by Thurmond (2001) namely data source triangulation, investigator triangulation, theoretical triangulation and data-analysis triangulation.

In this study, two of these types of triangulation were employed. Multiple data sources were used to collect data and multiple measures for data collection were employed. Creswell (as cited by Stavros & Westberg, 2009) refers to data triangulation as using various data sources that collects data at different time intervals, different sources or in different scenarios to increase the confidence, credibility and validity in the findings. During this study, data triangulation was employed by making use of semi-structured interviews, observations and questionnaires.

1.6 POPULATION AND SAMPLE

Population is described by Struwig and Stead (2001) as the entire aggregation of elements from which a sample is to be selected. The entire population for this study consisted of FET science educators who use apps as resources in their classrooms.

Sampling is divided into two sets, the non-probability and probability sampling methods, where the non-probability sampling relies on the discretion of the researcher (Tustin *et al*., 2005). This study was conducted in the interpretative paradigm, using the case study method, making use of a non-probability sampling, where participants were purposefully selected and descriptive comments drawn from the sample (Guarte & Barrios, 2006).

The sample strategy for this study was a purposeful sample (*cf.* Section 3.6). The participants were chosen because they met the criteria set out by the researcher (Struwig & Stead, 2001). The sample size according to Luborsky and Rubinstein (1995) depends on the nature of the study, however, this study focused on a smaller sample so that the researcher could concentrate in depth on the participants' views and use this to draw the required guidelines, according to Guarte and Barrios (2006), also very few teachers met the criteria set out by the researcher (see below) when the study was conducted. Only a handful of schools were employing apps during their lessons and even fewer were applying these tools to their science lessons.

The sample for this study was therefore selected in terms of the following criteria:

- Qualified science educators;
- Educators with more than two years teaching experience;
- Educators using apps as aids and teaching resources;
- Educators in the FET phase;
- Educators who have selected apps for their classroom

A group of three FET science educators that met the above-mentioned criteria was selected as follows; one from a private school; one from an urban school and one from a rural school, with each participant bringing different aspects to the research. The participation was voluntary but the sample was predefined in terms of their qualifications and occupations, therefore it can be argued that a quota sample was being used (Tustin *et al.,* 2005).

1.7 DATA ANALYSIS

No statistical data were drawn from this survey, data were rather analysed in an on-going iterative or non-linear process and therefore data collecting, processing, analysis and reporting are entangled (Maree, 2007). A qualitative approach was used to analyse the responses drawn from this study (*cf.* Section 3.8). Fade and Swift (2010) argue that the researcher is the main instrument of data analysis during qualitative research and either a literal or inductive approach can be applied to the data-analysis process.

The main goal of data analysis in an interpretive study is to produce an in-depth understanding of the context (Struwig & Stead, 2001). It is argued by Forsythe (1987) that the strength of analysis in the interpretative study lies in the interpretation of data and the explanations drawn.

According to Klein and Myers (1999) hermeneutics is one mode of analysis associated with interpretative research (*cf*. Section 3.8.1). The hermeneutic approach suggests a way of understanding the meaning of data or text correspondents (Klein & Myers, 1999). Hermeneutics is described as the 'art' of interpretation (Abulad, 2007), where the researchers and the participants must draw an understanding based on the interaction between all systems, where the hermeneutic circle evolves as a complex interaction of sharing (Klein & Myers, 1999). The principles of the hermeneutics circle (*cf.* Section 3.8.1) require the researcher to understand the situations in parts and as a whole to assign reasons to them (Miall & Miall, 2004). To assist the researcher with the task of making sense of data the researcher employed Creswell's (1994) template for case study analysis namely: within-case, cross-case and holistic-case analysis.

1.7.1 Data coding

Responses from the semi-structured interviews and questionnaires were coded and categorised accordingly to highlight the characteristics of selected resources and guide the researcher to present the final product, the proposed set of guidelines to select apps. Coding enabled the researcher to retrieve and group data (Tustin *et al*., 2005; Robinson, 2013; Maree, 2007; Fade & Swift, 2010). Coding can occur as 'inductive coding', where no pre-set codes are determined and the data are used to reveal probable codes or 'priori coding' where codes are developed before the data are collected (Maree 2007). It is argued by Seidel and Kelle (as cited by Maree, 2007) that coding can act as a method to present findings in a transparent manner and a tool to steer future investigation (*cf.* Section 3.8.2).

1.7.2 Trustworthiness

It is argued that in qualitative research the researcher is the data-gathering instrument therefore although 'reliability and validity' may generally refer to quantitative research, 'credibility and trustworthiness' would be a main focus of qualitative research (Maree, 2007). Trustworthiness refers to the trust in the output, where the data collected are true and the argument drawn is strong (Mauthner & Doucet, 2003).

1.8 DISSEMINATION OF FINDINGS

The research findings will remain the property of the University of Pretoria. The results of this study may be used for a research report and journal articles. Participants' identities are not disclosed and all details regarding the schools are handled as strictly confidential. No names of participants or schools were provided in any publication or public presentation to ensure anonymity.

1.9 DELIMITATIONS AND LIMITATIONS

The research was limited to a certain extent by time available for primary research and the scarcity of electronic devices in the education system in a developing country like South Africa. Some educators have only a basic command of the English language and the researcher dealt with this during the study by explaining questions clearly to educators during interviews to ensure that all questions were fully understood.

The boundaries used to select participants placed a limitation on the participant. The researcher only investigated science educators in the FET phase who are currently using apps to assist in their teaching. This limited the schools that could be selected and as a result some schools were far and made it difficult to visit more than once, due to cost and logistical arrangements.

1.10 ETHICAL CONSIDERATIONS

Williams (2000) states that ethical clearance refers to a number of national and internationally recognised principles that provide a researcher with guidelines on how to conduct research in an ethically approved manner.

The researcher obtained ethical clearance from the Faculty of Educations' Ethical Committee, consent from the headmasters from the two schools in the Gauteng region and from the headmaster from the Eastern Cape school (*cf*. Appendix 10.1.1). Informed consent was given by the individual participants with regard to participation and presenting the data in any publications (*cf*. Appendix 10.1.2). The CSIR obtained ethical clearance for the Tech4RED project from the Department of Education in the Eastern Cape and internal ethical clearance from the CSIR board to commence research.

Participation in this study was voluntary and participants could withdraw from the study at any time. The participants were kept anonymous and all information shared with the researcher was handled as confidential.

All data-collection documents will be kept by the University of Pretoria and the researcher for fifteen years. The issue of objectivity was addressed by not using any friends or colleagues of the researcher during this study. Finally, the results and data collected from this research were made available to all participants.

CHAPTER OVERVIEW

Figure 1-5 below illustrates how the research is presented:

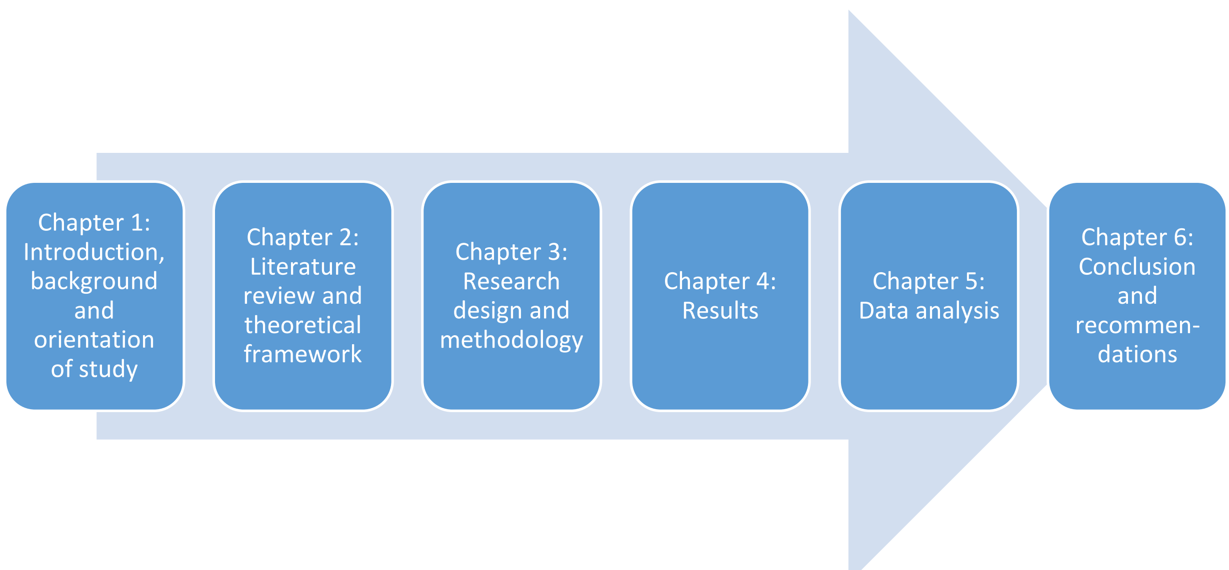


Figure 1-5: Chapter outline (source: The researcher)

This study is reported on in six chapters. An overview of the remaining chapters is briefly outlined below:

- Chapter 2 considers the literature that deals with mobile learning, the selection of the correct resources for science teaching and how these resources can support inquiry-based teaching.
- Chapter 3 presents a review of the research methodology used in the study.
- Chapter 4 presents the data collected.
- Chapter 5 describes the exploration of the embedded units of analysis and reports the analysis and findings.
- Chapter 6 contains an overview of the study, the conclusion and further recommendations for further research.

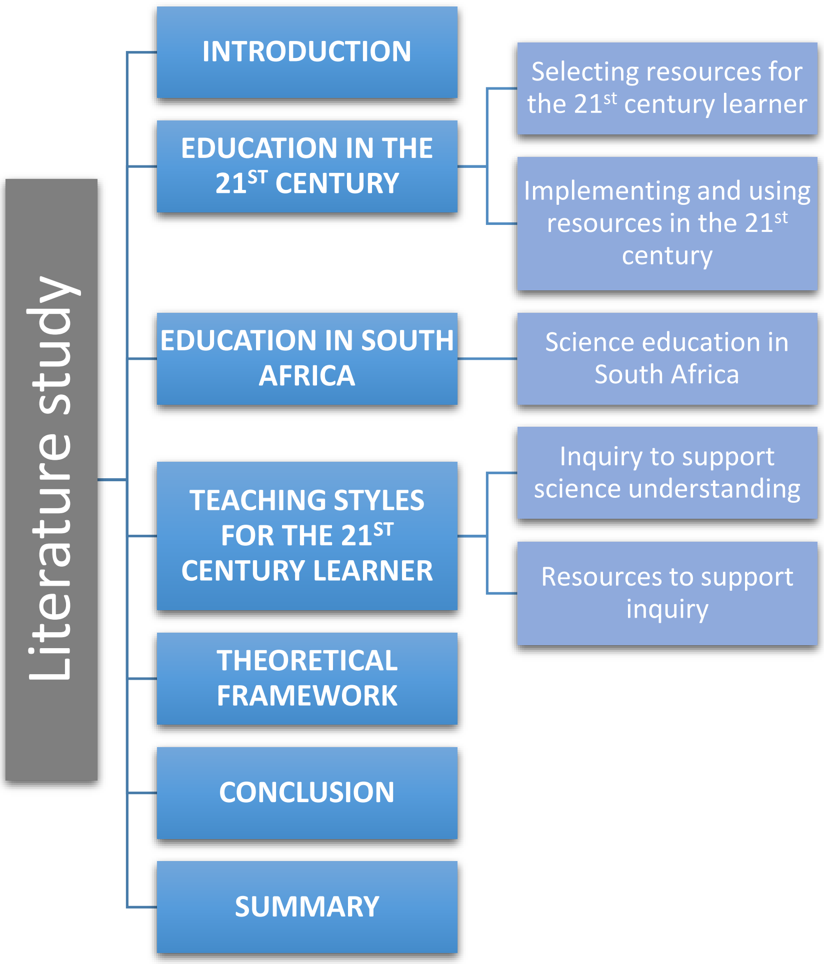
1.11 CONCLUSION

Chapter 1 provided an overview of the proposed research study by providing background information, stating the problem identified, the aims and objectives, the research design and the research process, ethical consideration and chapter outlines. Finally, this chapter also indicated that the study could make a valuable contribution to the field of science education and in the area of selecting resources for the 21st century.

Chapter 2 focuses on the literature review and proposes to identify possible factors used to select resources for science classrooms and also identify the principles of inquiry-based teaching. Chapter 2 also elaborates on the theoretical framework applied to this study, the TPACK-framework indicating each component of the framework and how it is theoretically explained by experts.

2. CHAPTER 2: LITERATURE STUDY

Map of Chapter 2: LITERATURE STUDY



2.1 INTRODUCTION

Chapter 1 stated the problem, the research questions, methods used to conduct the research as well as how the sample was selected and a summary of how data would be analysed. Chapter 2 focuses on the literature review and investigates other sources to ensure that the researcher is not 'reinventing the wheel'. The review searches for views on inquiry-based teaching, selecting resources for science and the introduction of technology to a South African science classroom. The problem of moving from traditional resources to mobile resources and the vast challenges educators' face is one of the important aspects looked at in chapter 2. Immense changes are taking place in our socio-cultural, economic and technological fields and we can only assume that we have to adapt our teaching and resources to fit a new generation of learners (Crawford, 2007), an original generation, one of vast technological development according to Veen (2006).

2.2 LITERATURE REVIEW

2.2.1 Education in the 21st century

Researchers claim that today's students belong to a 'computer based' (ICT) generation due to digital technologies available (Veen, 2006; Becker, Fleming & Keijsers, 2011 & Johnson, 2015). They elaborate that this 'new' generation view education and training in a different light (Becker *et al*., 2011 & Higgins, 2014). This ICT generation is a group of individuals who can multi-task, will analyse icons before text, are always connected via technology, prefer to work together in teams and learn by searching for, playing with and externalising information (according to Prensky as cited by Veen, 2006).

Technology has become the new differentiator in education, argues Colin Thornton (Independent Education, 2013). Zawilinski (2009) and Johnson (2015) suggests that the internet is this generation's defining technology and each new technology, whether e-mail, blogs, wikis, or search engines requires new skills and strategies. These new skills should be integrated into the curriculum according to Leu, Kinzer, Coiro and Cammack (2004) to ensure our scholars are prepared for a new workplace; however, that is easier said than done. According to John and Sutherland (2004) and Hodgkinson-Williams (2005) the implementation of ICT in education faces challenges both globally and in South Africa. The introduction of technology to any school is a complex process, but seems more complex for schools where limited resources were in place before the introduction of ICT (DofE, 2003).

Jonassen, Peck and Wilson (1999) suggest that we need to move towards learning through the use of ICTs rather than the traditional view of learning about ICTs. This brings us to the next idea, which is that the correct resources should be selected to correctly address the Google-based generation.

2.2.2 Selecting resources for the 21st century learner

Teachers cannot improve their quality of teaching without sufficient combinations of textbooks and other classroom resources (Van der Berg, 2008). The correct resource combination is also considered important; Diamond (2012) argues that optimum learning involves individuals interacting and responding successfully to information and learning situations, however according to Veen (2006) the ICT-generation showed different behaviour patterns in dealing with information and communication and we can therefore assume that a new approach is needed to select resources for this generation.

Electronic learning (e-learning) or mobile learning (m-learning) has been a topic growing in popularity in education recently where it refers to the use of any electronic media, information and communication technologies (ICT) in education (Mishra *et al*., 2000). Mobile devices according to Traxler (2007) can be defined as “any educational provision where the sole or dominant technologies are handheld or palmtop devices”. Turunen, Syvaenen and Ahonen (2003) go further to explain that mobile devices are a pervasive medium that may assist us in combining work, study and leisure time in meaningful ways. It is also proposed by Sharples *et al.* (2005) that it is in fact the learner that needs to be ‘mobile’ rather than the technology, referring to the learner being skilled to move between settings, including mobile devices, computers, as well as books and notepads.

Computerised material is classified as an ‘assisting tool of instruction’ according to Santoro and Bishop (2010) when they include intended learning goals, instructional strategies and consist of learning materials and activities that could include assessments as well. Applications (apps) are a version of computer software meant for any mobile device like a mobile phone, tablet or portable media player (Rishi, 2012). Mobile applications are explained by Botha (2011) as the use of specific technology or a variety of technologies that are available on the device. A mobile device is likely to have more than one application platform that would allow the development of local applications (Botha, 2011).

Apps are designed to fulfil the needs and requirements of the mobile users (Love, 2005). According to MMA (2008), mobile applications can run as:

- Connected mobile applications: applications that require network connection to perform the majority of its tasks. For example: mobile web browsers, social networks, streaming multimedia applications and mapping applications.
- Intermittently connected mobile applications: occasional network connectivity required to perform it tasks. For example: e-mail, banking applications, newsreaders and currency converters.
- Non-connected mobile applications: software that does not require network connectivity to perform the majority of tasks. For example: games, video or audio players, productivity applications and file managers.

Technology must aim to enhance teaching and learning and the process to select resources is one part to ensure the correct apps, materials or textbooks for education (Losavio, Chirinos, Levy & Ramdane-Cherif, 2003). We can therefore conclude that the process to select the correct digital tools is one that could be further investigated.

The five principles of meaningful learning with technology are proposed by Jonassen, Howland, Marra and Crismond (2008) as active, constructive, intentional, authentic and cooperative. It is recommended that meaningful learning is far more likely if the new technologies are providing transformative opportunities (Jonassen *et al.,* 2008).

This brings us to vital questions, 'who selects the resources used by educators' and 'what process is used to select these educational resources'?

2.2.3 Implementing and using resources in the 21st century

Using technology signifies a person connecting with an interactive computing device or mobile program. User experience is a concept focused on the user as an individual and is considered a personal experience affected by both the technology used and the users' prior-knowledge and former experiences (Hassenzahl & Tractinsky, 2006). Due to the complexity of the user and the multitude of factors influencing the users experience researchers can merely compare all the interactive components and attempt to understand the complex situation (McCarthy & Wright, 2004 & Roto, 2006).

When introducing ICT to a curriculum or school, according to Puentedura (2006) there are four stages of ICT integration, as shown in figure 2-1 below.

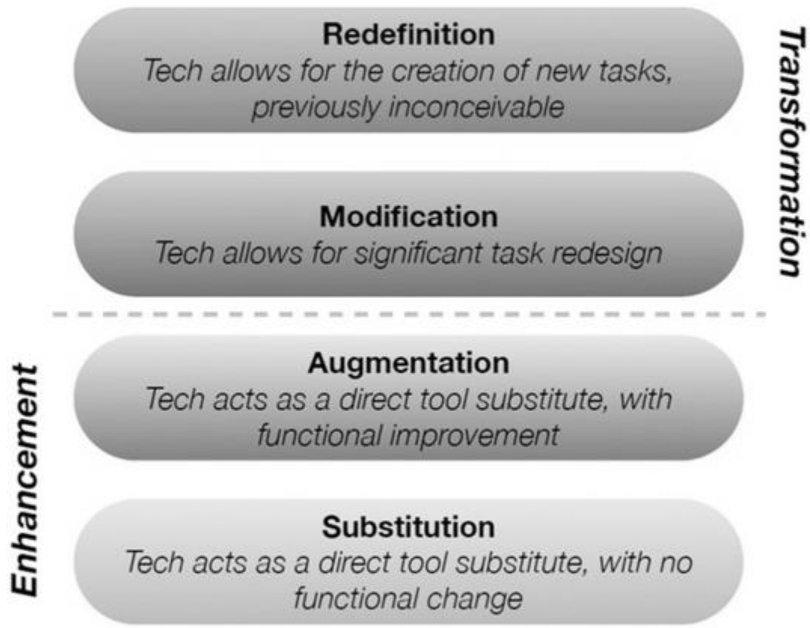


Figure 2-1: SAMR Model of technology integration (source: Puentedura, 2006)

The above SAMR-model by Puentedura (2006) essentially illustrates the impact of innovative usage of technologies to transform learning. The model proposes that technology integration falls on the continuum among substitution, augmentation, modification and redefinition (Puentedure, 2006). The SAMR model represents the interconnection between technology, pedagogy and content and Hogan (2010) suggests that this model can assist teachers in addressing pedagogical changes when technology is introduced to lessons. When technology is only used in a substitutionary way Herrington, Herrington, Mantei, Olney, and Ferry (2009) claim that the effect on learning is lessened and the goal should be to reach the redefined level where technology drive the creation of new innovative tasks. Furthermore, Hokanson and Hooper (2000) agree with the above-mentioned ways to integrate technology, firstly the representational integration and secondly the generative integration. The difference according to Hokanson and Hooper (2000) is that during the representational integration material is 'reproduced' on a device and the generative approach refers to the process of 'construction of knowledge' by an individual.

The ICT4RED initiative used the following principles for implementing technology in rural schools in South Africa: having minimum school disruption, flexibility with school structure, developing local capacity, reflect, and improve, working within the system, positive reinforcement, create safe places and finally be education focussed (Herselman & Botha, 2014).

With the rapid technological development self-directed learning is a necessity for the 21st century learner according to Yan, Thai and Bjork (2014). ICTs are seen as 'cognitive power' to employ during thinking, problem-solving and learning by Jonassen and Reeves (1996) and Beaucamp, Jazvac-Martek and McAlipine (2009). Therefore it can be suggested that when considering new technological resources these factors might be vital in addressing the effective training of future generations. This brings us to the idea of education and integration of resources locally to accommodate the South African science learner.

2.2.4 Education in South Africa

Sadly South Africa ranked almost last in more than one international test that compared students' mathematics, science, reading and technology skills. Out of more than 140 countries as seen in figure 2-2 below, South Africa ranked almost last according to their skills in mathematics, reading (English) and science skills (World Economic Forum report, 2013).

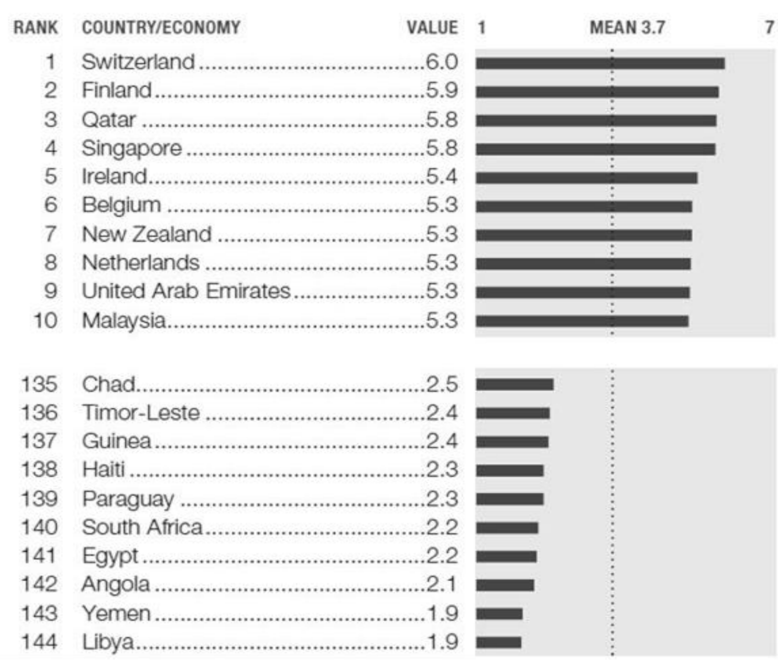


Figure 2-2: International comparison of math, reading and science skills among students (source: World Economic Forum report, 2013.)

In another comparison, the Global Information Technology Report, South Africa was placed in 70th place according to the country's development and skills in information and communication; however, the report goes on to explain that under the "skills" sub-category, South Africa's mathematics and science education comes in last place (NRI, 2014). In yet another test, the local Annual National Assessments (ANAs), which tests 7.3-million pupils mathematics and English skills showed a 10.8% score for Grade 9 mathematics, down by 4.2% from the previous year (John, 2014).

Mabila, Malatje, Addo-Bediako, Kazeni and Mathabatha (2006) argue that the poor performance in South Africa's Grade 12 results is due to the following factors: a lack of discipline, inadequate resources, poor morale, and problems in the employment of policies, poor parental involvement, inadequate transfer of relevant skills, classroom environment and pupil-teacher ratio. In this time of educational reform, there has been considerable attention given to the change required in education in the hope to save the outcome (Van der Merwe & Sloman, 2014 & Bybee & Fuchs, 2006).

2.2.5 Science education in South Africa

Science is generally perceived as a subject that opens doors and creates endless opportunities, and therefore it is described by Van der Walt and Maree (2007) as a critical subject in secondary education. We can therefore conclude that adequate learning facilitation in this subject is of pivotal importance (Van der Walt & Maree, 2007).

Individual learning is complex enough and we aim to investigate the complex social context of a science classroom which is located in the broader school environment and according to Anderson (2007), this complex working of a school is shaped by society, social, political and economic aspects. This complexity is explained with the help of a diagram below in figure 2-3. As seen below, processes intended to produce change in educational practices must include both curricular and instructional aspects, rather than just the one or the other (Anderson, 2007).

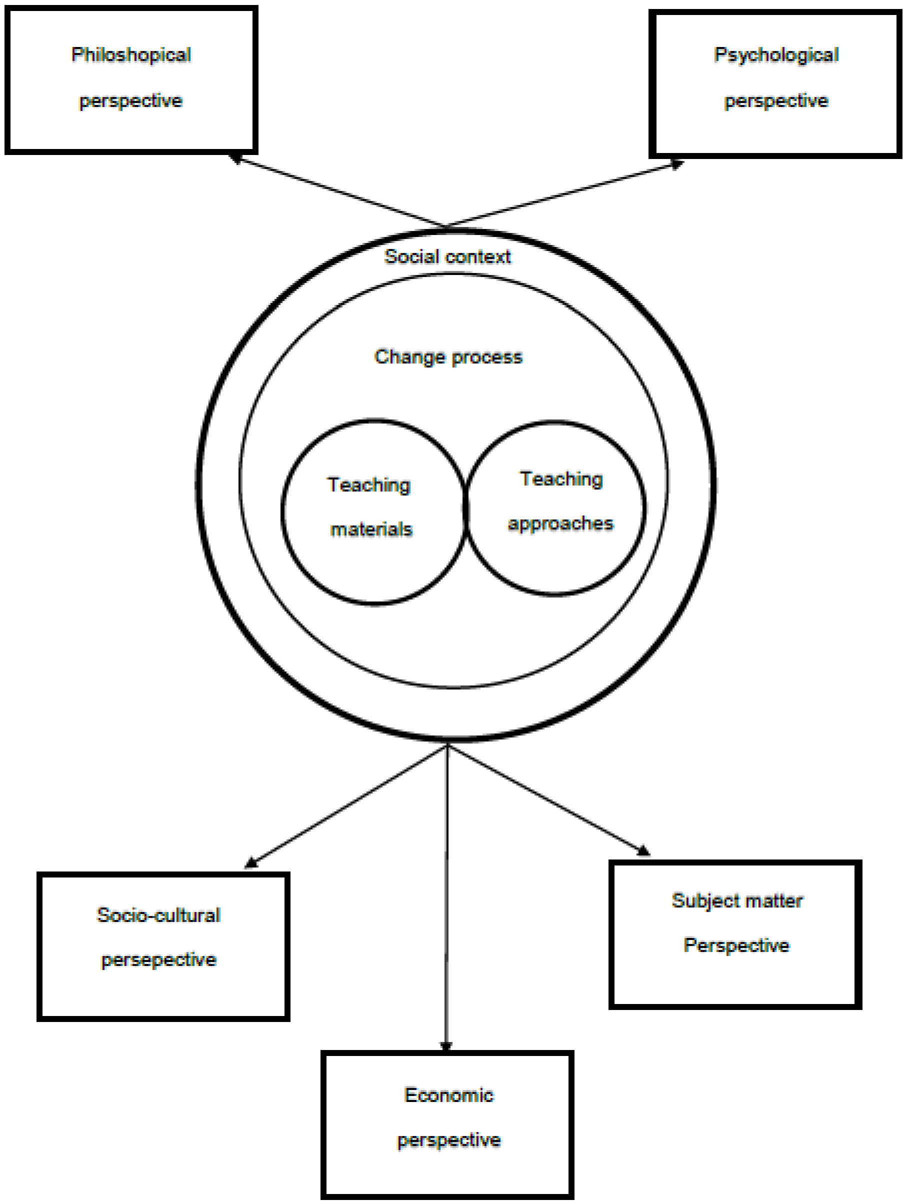


Figure 2-3: Illustrating the complex social context of a science classroom (source: Anderson, 2007)

As seen in figure 2-3 above, changing curriculum material or teaching approaches alone will not bring about successful change, according to Anderson (2007) change will only be successful if the right mix of initiatives is effected in the context of the right climate and support. As seen above in figure 2-3 the correct educational material and approaches can ensure change if it is applied in the correct social context, taking in account all aspects of society; namely: the philosophical perspective, the psychological perspective, the socio-cultural perspective, the economic perspective; and the subject matter perspective.

Science is a complex subject according to Bahru (2010) but according to Berlin and White (1995) for some science and mathematics are naturally and logically related. They go on to explain that learners' achievements are based on how they experience, organise and think about science (Berlin & White, 1995). Therefore it is suggested by the same researchers that learners should be involved in a learning environment that encourages pattern-seeking, exploring big ideas and finding the interrelationships between concepts and processes (Berlin & White, 1995).

Berlin and White (1995) stress the importance that science should include a broad range of content, provide sufficient time for seeking knowledge, and provide opportunities to use laboratory instruments and deploy the latest technology. According to Anderson (2007) inquiry teaching is one of the methods of inquisition to observe the world and propose explanations of what is happening around us, this is proposed as one of the best forms to explore scientific knowledge (Trautmann, MaKinster & Avery, 2004; La Lopa, 2013; Cothran & Kulinna, 2006; Sandifer & Lottero-Perdue, 2010; Lin *et al*., 2012).

The Department of Education (2002) suggested in the revised South African school science curriculum that an inquiry-based approach to learning should be followed, one where learners are exploring objects, discovering situations and events in their immediate environment, to discover new methods to collect data, to report on data collected and ultimately draw accurate conclusions (Department of Education, 2002). The inquiry-based teaching of science is also included in the Curriculum and Assessment Policy Statement (CAPS) document that states that science is a subject that "promotes knowledge and skills in scientific inquiry and technological knowledge; an understanding of the nature of science and its relationships' (Department of Basic Education, 2011). Are some teaching styles better suited for specific subjects and would employing the correct teaching style offer better results?

2.2.6 Teaching styles for the 21st century learner

Teaching styles are one of the aspects especially in science and mathematics that are explored by some researchers in the hope to progress students' scientific understanding and motivation and in turn improve their results (Visser *et al*., 2014; Salpeter, 2008; Gibbs, 2003 & Shepherd *et al*., 2010).

'Inquiry' teaching refers to a study of the natural world and drawing explanations from evidence, also called an 'active process' (Taylor, 2015 & Anderson, 2007). Minner *et al*. (2010) define inquiry learning as a fragmentary process where individuals find meaning through the selective gathering of information and the effective integration or replacement of existing knowledge. According to Anderson (2007), there are four elements that attempt to explain inquiry teaching; namely:

- Individuals should be actively constructing and finding meaning for themselves;
- An individual's prior conceptions may need to be modified before meaning can be found;
- The individual's understandings are dependent on the context in which the meanings are drawn; and
- Meaning is affected by the society.

The thought processes are broken down into four steps according to Minner *et al*. (2010) and Sherifat (2014), where learners should be engaged by questions, they evaluate and formulate explanations based on evidence and lastly they would compare their own explanations on alternative explanations. Bahru (2010) puts forward the notion that inquiry-based teaching consists of: the active involvement of students, hands-on learning, experiments and activities, an approach to discover knowledge, development of skills to follow method and process, which correlate with the scientific method. Students' experiences are classified as constructing mental frameworks that try to explain their experiences (Bahru, 2010).

2.2.7 Inquiry to support science understanding

Inquiry-based teaching is argued to be a desirable and effective method to teach science subjects according to Taylor (2015); Bahru (2010) and Trumbull, Scarano and Bonney (2006), due to the fact that it encourages scientific research and investigation. It is continually argued that inquiry-based teaching promotes scientific literacy and in turn improves students' understanding and engagement in science (Hodson, 1993; Minner *et al*., 2010 & Schwartz, Lederman and Crawford, 2004).

One can only teach what one knows (Cubukca, n.d; Smeets & Mooij, 2001) and Onwu and Stoffels (2005) identified teacher competence as a key factor of concern in the implementation of inquiry-based teaching. Colburn (2000) stated that teachers are responsible for the implementation of inquiry-based teaching and learning in South Africa due to the fact that teachers are the decision makers in their classrooms. Capps and Crawford (2013) and Taylor (2015) propose that teachers will have to develop an adequate understanding of inquiry teaching, their own abilities, the pedagogical skills required to teach inquiry and the intention to teach in this manner. Crawford (2000) and Lin *et al*. (2012) also put forward that teachers have to develop their content knowledge, pedagogical content knowledge and theoretical knowledge before inquiry-based teaching can be imparted successfully. For a teacher to ask higher-level cognitively based questions that encourage inquiry-based learning Chaney, Hammer, Sander and Rivers (as cited in NRC, 2005) suggest the teacher must have a high level of content knowledge and teaching experience.

Inquiry-based teaching enhanced scientific literacy and deeper understanding of science processes, scientific vocabulary, conceptual understanding, critical thinking and positive construction of logical mathematical knowledge according to Bahru (2010). Deboer (2002), Trumbull *et al*. (2006) and Gibson and Chase (2002) reported that inquiry-based teaching stimulates the learners' interest in science. Inquiry–based teaching improves understanding of scientific concepts (Westbrook & Rogers, 1996 & Quintana, Zhang & Krajcik, 2005) and scientific knowledge (Quintana *et al*., 2005). Collaboration between learners is a benefit suggested by Hofstein and Lunetta (2003) and Drayton and Falk (2001) that is promoted through inquiry-based teaching.

In other research findings it is suggested that inquiry-based teaching is especially valuable to under-served and under-represented populations (Bahru, 2010). It is also shown that students who are instructed with the help of inquiry-based teaching were found to acquire scientific ways of thinking, articulating and writing easier (Minner *et al*., 2010 & Bahru, 2010). Bahru (2010) goes on to explain that for inquiry-based teaching to be the norm in education, a process that would encourage students to become the creators of knowledge themselves, a big shift is required.

Teachers face dilemmas of poor results but Anderson (2007) found that teachers avoid inquiry-based science teaching due to the following reasons:

Time: inquiry-based teaching takes more time and educators try to move away from excessive preparation.

Ideal vs. reality: introducing more inquiry-based learning is limited due to the amount of theory that must be taught.

Changing roles and work: the school culture's expectations of teacher and students has changed. Changing the way we teach implies more complicated and time-consuming processes.

Preparation ethic: the school culture focuses on the next level of schooling and this fact is the driving force for the work done today in the classroom. Teachers fear that the inquiry-based science education will force preparation to suffer.

Equity: teachers feel inquiry-based science will provide a challenge for the able and willing students but pose a problem for the uninterested or less able student.

From this list proposed by Anderson (2007), it may be obvious that reforming science education toward a more inquiry-based strategy will demand a multifaceted approach. It is suggested that it is essential to have new instructional approaches, revised teaching materials, substantial means of implementation including teacher support and context or collaboration, along with attention to the social context among others (Anderson, 2007).

The main orientation 'shift' is exemplified below in table 2-1 to promote inquiry-based education in science:

Table 2-1: Orientation shift from traditional teaching to inquiry based teaching (source: Anderson, 2007)

Teacher role Traditional education: → A dispenser of knowledge	Inquiry based education: A coach or facilitator
Student role: Traditional education: → A passive receiver	Inquiry based education: A self-directed learner
Work: Traditional education: → Teacher prescribed activities	Inquiry based education: Student directed learning

As seen above in table 2-1, Anderson (2007) suggested teachers have to move from transmitting information, communicating with individuals, directing student actions, using a textbook to a new orientation of helping students process information, coaching student actions in groups, facilitating student thinking with flexible use of materials. The students' role must also change from the passive receiver that records the teacher's information, memorizes information, and follows the teachers' directions to the new orientation of actively processing information, interpreting and analysing data, design own activities in the search for answers (Anderson, 2007).

This approach will cause the nature of work done to change from a teacher-orientated focus where the students complete worksheet, all students complete the same tasks, teachers direct tasks to a new student-directed learning environment where students direct their own learning, task vary among students, directing and designing their own tasks (Anderson, 2007 & Abd-El-Khalick *et al*., 2004).

Taylor (2015), Banathy (1991) and Fullan (1991) suggest a stepped approach to educational change should be followed that has proved to be sustainable. Inquiry teaching is a practical theme for the science curriculum, but we still face the issue of how to change teaching practices in classrooms to aid the desired inquiry orientation (La Lopa, 2013). According to Anderson (2007) when investigating the various factors affecting change in education, two stand out, viz. the curricular material and the teacher. This brings us to the idea that to enhance inquiry-based teaching the correct resources should be selected to support the shift from a traditional classroom to an inquiry-based classroom.

2.2.8 Resources to support inquiry

Accurate selection of resources would ensure that the correct message is transferred to the right audience using the best available tools (Fullan, 1991 & Chadwick, 2012). Anderson (2007) goes on to state that well thought-through inquiry-based material can be the foundation of effective education.

We therefore look at the following background information regarding inquiry-based teaching. Inquiry teaching is a method of inquisition to observe the world and propose explanations of what is happening around us (Dewey, 1993; Westbrook & Rogers, 1996 & Anderson, 2007) and educational software should be selected to support this fundamental principle in science. Educators should therefore, according to Crawford (2007), be taught to filter and use educational software in such a way that it is supporting the inquiry nature of science subjects rather than hindering the process. Anderson (2007) supports this idea by proposing four characteristics that materials for inquiry-based science education should follow:

1. Instruction: teaching and assessment tools should optimize students' learning;
2. Inquiry-based: the ability to apply inquiry-based skills to scientific concepts;
3. Conceptual framework: based on a carefully developed conceptual framework that incorporates both science disciplines and connects science information to larger ideas and concepts; and
4. Revised and tested: revised to provide developers with information about the effectiveness of the materials used.

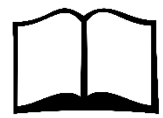
Good curriculum materials have been presented as an important vehicle to facilitate inquiry-oriented science education, Anderson (2007) and La Lopa (2013) argue that without the appropriate material the change toward inquiry-based teaching is not possible. Lin *et al*., (2012) also argue that inquiry-based teaching relies heavily on curricular resources and materials used in the classroom. Materials are demanding of teachers to alter their lessons when moving towards a student orientation from the previous teacher's orientation (Anderson, 2007). Anderson (2007) goes on to explain that previous research has shown that teachers feel that one factor that hinders them from using more innovation in education is the lack of time. Teachers struggle to find the appropriate amount of time to prepare resources and look for alternative methods (Anderson, 2007).

A big shift has to occur for inquiry-based learning to be the norm in the world of education (Hahn & Gilmer, 2000 & Bahru, 2010). Teachers should be facilitators who surrender their control, in an environment where learners are directing and shaping their own inquiry (Hahn & Gilmer, 2000 & Bodner & Hutchinson, 2014). Learners should be taught in a manner that would encourage them to shape the education they receive and inspire them to become creators of knowledge themselves (Hanh & Gilmer, 2000 & Bahru, 2010). Ernest (1989) found that two teachers with the same knowledge still taught in different ways and therefore suggested that change occurs successfully when one alters one's beliefs to eventually affect behaviour.

2.3 RESULTS OF LITERATURE REVIEW

The literature review provided an in-depth investigation into 'factors' that are suggested by authors to use to select the correct educational resources to support the social and historical background. Various authors suggest factors to consider when selecting resources for educational purposes. Below, in table 2-2, various 'factors' with supporting references from the authors are summarised. These identified 'factors' were used to design the research instruments. The research would confirm whether these ‘factors’ could be used as proposed guidelines to use when selecting apps to support science teaching in the FET phase.

Table 2-2: *'Factors' identified from the literature review to investigate during the research (source: The Researcher)*

Proposed 'factors' to aid mobile applications selection: 	**Author/s:** 	**Supporting literature according to author/s:** 
Curriculum fit	**Berlin and White (1995)**	Factual conceptual knowledge should be encouraged with the use of technology
	Independent Education (2013)	Correct digital tools must support the teaching and learning process
	eSkillslearning (2012)	Correct resources for the age group
		Does the app enable you to do something that you couldn't do before?
		Does the app address various learning styles?
		Does the app provide feedback?
		How would using the app benefit students?
	Charland and Leroux (2011)	Assessing the context
	Jonassen *et al.* (2008)	Require learners to construct their own mental models to explain their experiences
		Intentional in that they are goal-directed and process-oriented

		Authentic as they are embedded in the "real world" or are highly complex and simulating the "real world"
		Intentional
	Koehler and Mishra (2005)	Technology is content sensitive
Interactive	**Berlin and White (1995)**	Encourage higher order thinking with the technology used
	Bevan (2008)	Context conformity in use
	Independent Education (2013)	Correct digital tools must support the teaching and learning process
	eSkillslearning (2012)	Does the app address various learning styles?
	Losavio *et al.* (2003)	Portability
	Charland and Leroux (2011)	Successful ways of implementation
	Jonassen *et al.* (2008)	Require active engagement by the learner to manipulate object and tools in the learning environment and then observe the results of their activity
		Authentic as they are embedded in the "real world" or are highly complex and simulating the "real world"
		Active
Scientific content	**Berlin and White (1995)**	Invoke real world applications
	Bevan (2008)	Context conformity in use
	Charland and Leroux (2011)	Assessing the context
		Successful ways of implementation
	Jonassen *et al.* (2008)	Are intentional in that they are goal-directed and process-oriented
		Constructive
	Koehler and Mishra (2005)	Technology is content-sensitive
Customisation	**Berlin and White (1995)**	Use software that allows for a range of experiences
	Bevan (2008)	Context conformity in use
	eSkillslearning (2012)	Correct resource for the age group

		How can the app be incorporated into the classroom
	Losavio *et al.* (2003)	Portability
	Charland and Leroux (2011)	Assessing the context
		Successful ways of implementation
	Jonassen *et al.* (2008)	Constructive
		Authentic
	Koehler and Mishra (2005	Technologies are malleable
Students' responses	**Bevan (2008)**	Productivity in use
	eSkillslearning (2012)	Does the app address various learning styles?
	Jonassen *et al.* (2008)	Requires active engagement by the learner to manipulate object and tools in the learning environment and then observe the results of their activity
		Requires learners to construct their own mental models to explain their experiences
Personal perception and experience	**Bevan (2008)**	Effectiveness in use
		Productivity in use
		Satisfaction in use: Likability, pleasure, comfort and trust
		Context extendibility in use
	Independent Education (2013)	A strong relationship with partners must be established
	eSkillslearning (2012)	Does the app enable you to do something that you couldn't do before?
		How would using the app benefit students?
	Jonassen *et al*. (2008)	Require of learners to construct their own mental models to explain their experiences
User-friendliness	**Berlin and White (1995)**	Use the appropriate technology for the task at hand
		Satisfaction in use: Likability, pleasure, comfort and trust
	Bevan (2008)	Effectiveness in use, Productivity in use
		Context extendibility in use

	eSkillslearning (2012)	Does the app provide feedback?
		How much instruction is required to use the app?
		How would using the app benefit students?
		How much instruction is required to use the app?
		Can the app assist you to work smarter, not harder?
	Losavio *et al.* (2003)	Functionality
		Reliability
		Usability
		Efficiency
	Charland and Leroux (2011)	The user experience
	Jonassen *et al*. (2008)	Cooperative
External sources	**Independent Education, 2013**	An expandable network
	Losavio *et al.* (2003)	Reliability
		Usability
		Maintainability
	Jonassen *et a*l. (2008)	Requires conversation, collaboration and cooperation with others in order to provide solutions to the tasks
		cooperative
Cost	**Bevan (2008)**	Minimizing unwanted cost
	Koehler and Mishra (2005)	Affordability
Appeal	**Bevan (2008)**	Effectiveness in use
		Satisfaction in use: Likeability, pleasure, comfort and trust

As seen above in table 2-2 ten 'factors' have been identified by the researcher from the literature review that are suggested by various authors to take into consideration when selecting educational resources (either traditional or electronic), evaluating the benefit of selected resources and judging the overall impact of the selected resources.

These factors are:

- Curriculum fit: factual, correct tools to support the teaching and learning process.
- Interactive: active engagement of learning linking to the 'real-world' setting.
- Scientific content: content is scientifically correct and goal-directed.
- Customisations: software allows for customisation to fit age, subject and content.
- Students' response: appealing to a range of scholars, various teaching styles incorporated in the resources, students construct their own knowledge.
- Personal perception and experience: likeable, benefiting scholars, can accomplish more than before.
- User-friendliness: effective, benefit scholars learning, reliable, usable and cooperative.
- External sources: an expandable network.
- Cost: minimizing unwanted cost, affordable to a wide range of scholars.
- Appeal: appealing.

These 'factors' as described above guided the design of the research instruments in terms of the questions asked during the interview, the factors observed during classroom observations and questions used in the questionnaire.

The literature review also provided an in-depth search for 'principles' that support inquiry-based as a teaching style to assist the teaching of science to ultimately improve scientific knowledge. Below, in table 2-3, are the suggested 'inquiry-based teaching principles' with supporting references from the various authors.

Table 2-3: 'Principles' identified from the literature review to investigate during the research (source: The Researcher)

Proposed 'principles' to aid mobile applications selection: 	**Author/s:** 	**Inquiry-based teaching principles:** 
Curriculum fit	Anderson, 2007	Individual's prior conceptions may need to be modified
		Actively constructing and finding meaning for themselves
		Dependent on the context
	Minner *et al*. (2010)	Effective integration or replacement of existing knowledge
	Bahru (2010)	Discovery of knowledge
		Correlation with the scientific method
	Healey (2005)	Particularly associated with the sciences
	Haury (1993)	Activity-based instruction
Interactive	Anderson, 2007	Explanations drawn from evidence
		Active process
		Actively constructing and finding meaning for themselves
	Minner *et al*. (2010)	Find meaning through the selective gathering of information
	Bahru (2010)	Active involvement
		Hands-on learning

		Experiments and activities
	Healey (2005)	Direct involvement in research
		Active learning
		Staff and teachers are co-learners
		Interaction with a range of learning experiences
	Handelsman, *et al.* (2004)	Group work
		Interactive computer based learning
	Haury (1993)	Active nature
		Activity based instruction
		Discovery approach
		Investigative nature of science
		Collecting and interpretation of information
		Investigations to satisfy curiosities
Scientific content	Anderson, 2007	Actively constructing and finding meaning for themselves
		Dependent on the context
	Bahru (2010)	Experiments and activities
		Discovery of knowledge
		Correlation with the scientific method
	Healey (2005)	Problem-based learning
		Particularly associated with the sciences
	Handelsman, *et al.* (2004)	Students as scientists
		Interactive computer-based learning
	Haury (1993)	Activity based instruction
		Discovery approach
		Investigative nature of science
		Collecting and interpretation of information
		Strongly employed by science teachers

		Investigations to satisfy curiosities
		Enhance student performance particularly their laboratory skills
Customisation	Anderson, 2007	Active process
		Actively constructing and finding meaning for themselves
		Individual's prior conceptions may need to be modified
	Bahru (2010)	Active involvement
		Experiments and activities
	Minner *et al*. (2010)	Find meaning through the selective gathering of information
	Healey (2005)	Staff and teachers are co-learners
		Innovative
	Haury (1993)	Investigations to satisfy curiosities
Students' responses	Anderson, 2007	Individual's prior conceptions may need to be modified
	Bahru (2010)	Discover knowledge
	Haury (1993)	Investigations to satisfy curiosities
		Enhances student performance particularly their laboratory skills
		Promotes positive attitudes towards science
Personal perception and experience	Minner *et al*. (2010)	Effective integration or replacement of existing knowledge
	Healey (2005)	Roles between teacher and student is minimised
	Haury (1993)	Promotes positive attitudes towards science
User-friendliness	Healey (2005)	Interaction with a range of learning experiences
	Handelsman, *et al.* (2004)	Interactive computer based learning
External sources	Anderson, 2007	Meaning is affected by the society
	Healey (2005)	Roles between teacher and student are minimised
		Multiple communities intersecting
		Interaction with a range of learning experiences

The literature review also provided an in-depth search for 'principles' that support inquiry-based teaching as a teaching style useful in assisting in the teaching of science to ultimately improve scientific knowledge. As seen above in table 2-3, eight 'principles' have been identified from the literature review that are suggested by various authors to take into consideration when employing an inquiry-based activity or task.

These principles are:

- Curriculum fit: prior conceptions need to be modified with the help of discovering of knowledge.
- Interactive: active process where scholars are constructing and finding meaning, with the help of hands-on experiments.
- Scientific content: discover learning, through experiments, problem-based interactive computer based learning.
- Customisation: active process where staff and scholars are co-learners.
- Students' response: discover knowledge through investigations to satisfy curiosity.
- Personal perception and experience: Integration or replacement of existing knowledge by means that would promote positive attitudes towards science.
- User-friendliness: interactive, computer-based learning.
- External sources: meaning of learning is affected by society, interaction of a range of learning experiences.

These principles were used to guide the development of the research instruments in terms of the questions asked during the interview, the factors observed during classroom observations and questions used in the questionnaire.

2.4 THEORETICAL FRAMEWORK

A theoretical framework is a set of concepts used to guide your research (Willis, 2007). To clearly plan the research undertaken, it is recommended to construct a conceptual framework which will simplify the research task and provide direction in the field of study (Fisher, Buglear, Lowry, Mutch & Transley, 2004). Saunders *et al.* (2003) suggest that a framework is also used to direct the analysis of the data in an efficient way.

The theoretical framework used to direct this study is the technological pedagogical and content knowledge (TPACK) framework by Koehler and Mishra (2009). According to Koehler and Mishra (2009) the model represents the three main components of teachers' knowledge: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK) as well as the essential interaction between the three components as seen in figure 2-4 below.

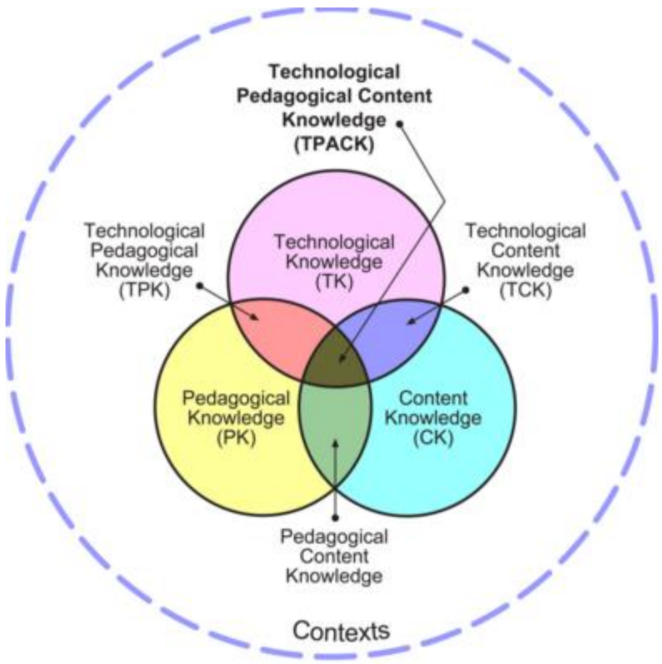


FIGURE 2-4: TPACK framework and its knowledge components (source: Koehler and Mishra, 2009)

As seen above in figure 2-4, the TPACK framework has a complex interplay among three primary forms of knowledge: content knowledge (CK), pedagogy knowledge (PK) and technology knowledge (TK) according to Koehler and Mishra (2009). These three components are not seen in isolation, for according to Koehler and Mishra (2009), the interactions among the three main components are represented as technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPACK).

To effectively integrate technology in a pedagogical content for a specific subject requires a successful relationship between the required components of the TPACK model that apply to the specific case (Shulman, 1986).

Each component, according to Koehler and Mishra (2009), refers to a specific knowledge field as explained below:

- Content Knowledge (CK): educators' knowledge of the subject matter. Shulman (1986) goes on to explain that this knowledge includes all theories, ideas and approaches associated with a specific subject.
- Pedagogical Knowledge (PK): educators' knowledge about teaching methods and styles that best support their subject. A deep understanding of how students learn the subject at hand and strategies to convey knowledge to scholars.
- Technology Knowledge (TK): an educator's knowledge of technological principles and methods to apply these tools and resources.
- Pedagogical Content Knowledge (PCK): the link between curriculum, assessment and pedagogy. The 'notion of transformation of the subject matter for teaching' according to Shulman (1986).
- Technological Content Knowledge (TCK): an educator's knowledge of how technology can support their subject content, or limit the subject for that matter. In this knowledge component there should be an interactive process between how the content dictates the technologies that would be suitable to employ.
- Technological Pedagogical Knowledge (TPK): an educator's understanding of how technology can change the teaching and learning process.
- Technological Pedagogical Content Knowledge (TPACK): the educators' knowledge of effective teaching with technology incorporating all components from the framework to ultimately have meaningful and expert teaching with technology.

2.5 CONCLUSION

The literature presents the notion that technology is not the sole solution to the problems in science or an instructional solution, but rather a connected process of instruction and technology together can enrich the learning environment to ultimately facilitate the development of student understanding.

2.6 SUMMARY

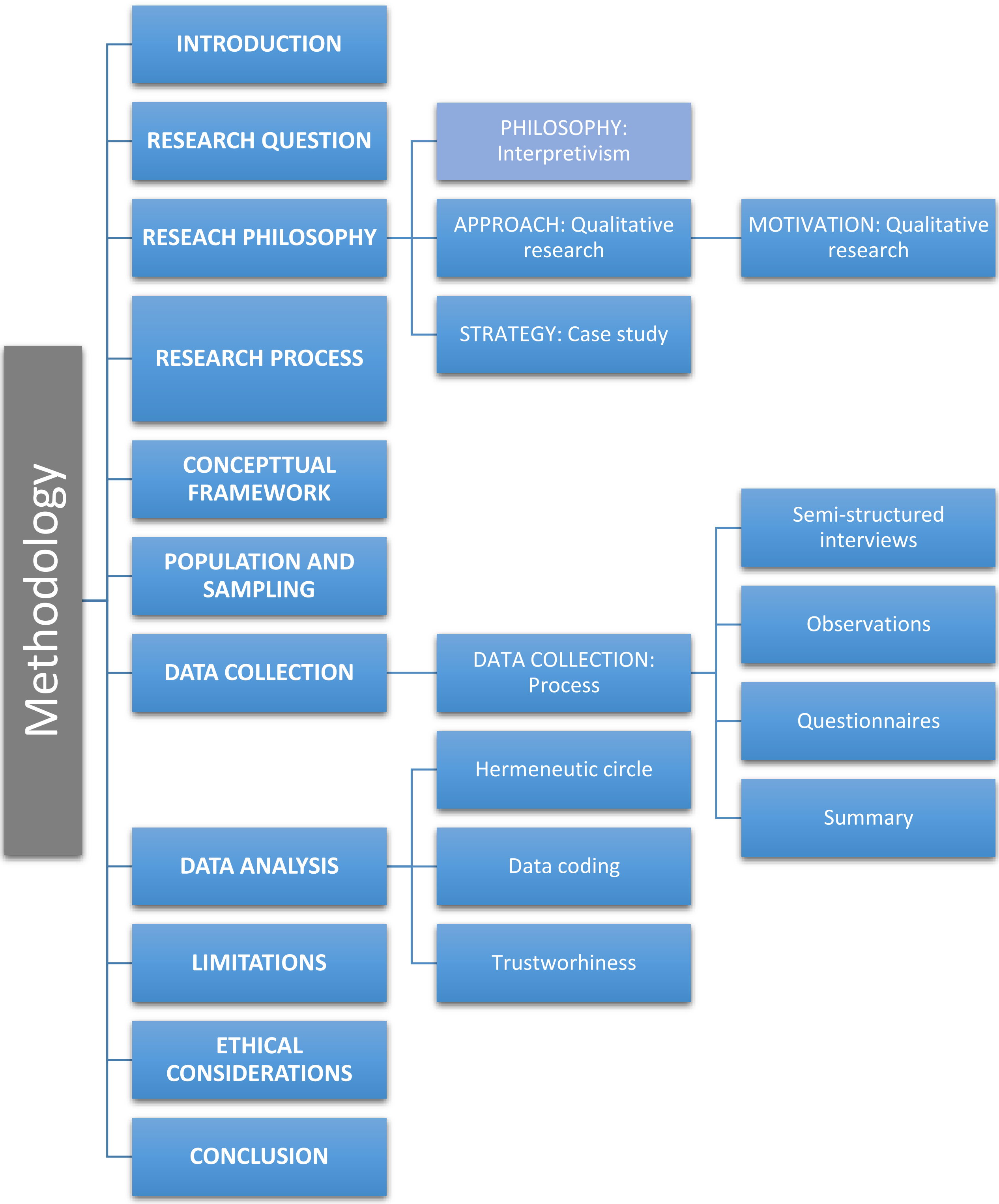
Chapter 2 focused on the literature that supports the study including the education reform in the 21^{st} century and how resources should be selected and used to accommodate the 21^{st} century learner. A list of ‘factors’ is proposed by means of literature to suggest how educators select resources for the 21st century learner.

The next section focuses on the education specific to the culture, scholars and requirements and how science are presented in South Africa. Inquiry-based teaching, a teaching style to accommodate a science learner in the 21st century is explored. A list of inquiry-based teaching ‘principles’ is identified. Both sets of guidelines are used to finalise a proposed set of guidelines to select apps for the FET science classroom that could support inquiry-based teaching.

Chapter 3 elaborates on the research design and methodology employed. Each component (from how participants were selected, the methods of collecting data, the data-collection instruments and how the conceptual framework was used in the study) is discussed in detail.

3. CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Map of Chapter 3: RESEARCH DESIGN AND METHODOLOGY



3.1 INTRODUCTION

The research methodology defines the process in which the research study was employed. The background, orientation and objective of the research methodology were briefly discussed in chapter 1.

In chapter 2 both a review of the literature and the theoretical framework were presented. In this chapter the research questions that were addressed are stated again and a detailed description of the philosophical assumptions underlying the research questions given. This chapter also sets out the research design, the research methods, population sampling, data-collection methods, data analysis and the measures to ensure trustworthiness of the study. Additionally, the chapter outlines the purpose and the objectives of the study in more detail.

3.2 RESEARCH QUESTION

The main aim of this research is to determine a set of guidelines with regard to:

- The selection of apps to support science teaching; and
- The use of apps to support science teaching.

The researcher hoped to find a set of proposed guidelines based on the feedback from the three case studies investigated. The specific objective of this research was to:

- Attain an understanding of the process educators follow to select apps;
- Conduct a study to explore how educators are employing the selected apps; and
- Investigate whether the use of the selected apps could support inquiry-based science teaching.

In the light of the former discussion, the key research question therefore is:

How do the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?

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

SQ1. What would determine the preferred selection or specific mobile educational applications for science teachers?

SQ2. How can the use of these mobile educational applications support inquiry-based teaching?

SQ3. How can mobile educational applications support inquiry-based teaching in science in a rural and urban context in South Africa?

The main objective of the study was to develop guidelines to support teachers in the selection of apps to support inquiry-based science teaching. The methodology used to answer the above mentioned research questions is discussed in more detail in the sections below.

3.3 RESEARCH DESIGN

It is argued that the selection of an appropriate research design for conducting research means that substantial thought has to be given as to what techniques will complement the study and provide the best modus operandi in gathering useful information (Saunders *et al.,* 2000; Saunders *et al*., 2003; Struwig & Stead, 2001; Hussay & Hussey, 1997).

A research design is a proposed course of action that needs to be followed to ensure the research objectives are successfully met (Maree, 2007). It is a process that consists of a systematic and methodological implementation of the research design (Maree, 2007).

The research design is based on a model that has been adapted from Saunders *et al.* (2015), referred to as the 'research onion', as seen in figure 3-1.

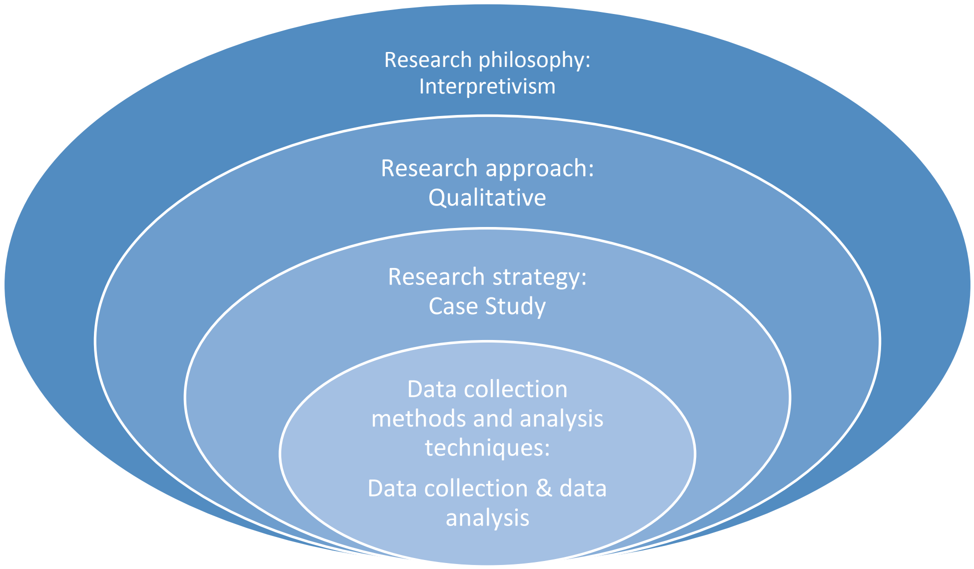


FIGURE 3-1: The adapted research onion (adapted from Saunders, Lewis & Thornhill, 2015)

The research onion is proposed by Saunders *et al.* (2000), it is the representation of each 'layer' of the study, and the aim is to move the study from the abstract ideas to the concrete data collection phase. The 'research onion' presented above in figure 3-1, will be used to explain each 'layer' of this study until the centre has been reached (Saunders *et al.,* 2000). According to Saunders *et al*. (2000), the centre of the research is the analysis of collected data and we can therefore argue that it is the reflection of the preceding layers. The first 'layer' to be discussed is the research philosophy supporting the whole research. The next 'layers' are the research approach, strategy and data collection and analysis techniques. The next section discusses the philosophical assumptions underlying the study and the succeeding layers found in the onion.

The researcher gathered qualitative data to answer the research question by means of semi-structured interviews, observations and questionnaires. The researcher must ensure that the thought process during data-gathering efforts needs to be methodical and should stand up to the closest scrutiny so that the results drawn would be reliable and useful (Saunders *et al*., 2003), especially during qualitative data gathering.

3.3.1 Philosophy: Interpretivism

Vogel (1997) argues that no single research methodology exists than can be seen as better than the next research methodology. According to Maree (2007), Bachman and Schutte (2003) and

Jackson & Sorensen (2007) there are several research perspectives that can be employed during research projects, three key perspectives of these are compared below:

Table 3-1: Comparison between research philosophies (adapted from: Jackson and Sorensen, 2007; Sprague, 2005; Terre Blanche, Durrheim & Painter, 2008; Maree, 2007; Bachman & Schutte, 2003)

Interpretivism	Positivism	Constructivism:
• Foregrounds the meaning that individuals or communities assign their experiences • Intersubjective meanings are crucial to achieving understanding and meaning • Behaviour is constituted by social conventions, interpretation is required, facts do not speak for themselves • No distinction between the subject (researcher) and the object (event) • Social context, conventions, norms and standards of the particular person or community are crucial elements in assessing and understanding human behaviour	• Only objective, observable facts can be the basis of scientific research • Theological (study of the supernatural) or metaphysical (the abstract) claims must yield to the positive • That which can be explained in terms of scientific law • Explain and predict what happens in the social world through systematically observing data for patterns and relationships among people • Attempt to test the predictive understanding of phenomena by assuming that reality is objective	• Nature of human learning • Constructivism refers to the nature of human learning and understanding • Perception is reality, which is influenced through social, spatial and historical context • Describe this paradigm as an interactive relationship emphasising the importance of exploring what people do and how they construct their beliefs in a social society • Knowledge and interpretation in a constructivist research paradigm is the result of perspective theory generation in a collective process

Morgan (1980) states a paradigm is any worldview that would include different schools of thought, different approaches or perspectives but similar fundamental assumptions about the nature of the reality that they address. This study searched for understanding by investigating people in their natural environment (Kelliher, 2005); in this investigation educators were observed in their classrooms. As stated by Kaplan and Maxwell (1994) one understands better by investigating the complexity of human understanding with the help of social constructions such as explanations, documents, consciousness and shared meanings.

Due to the nature of the study an interpretative paradigm was followed. The main characteristics of an interpretivism philosophy are presented below in figure 3-2.

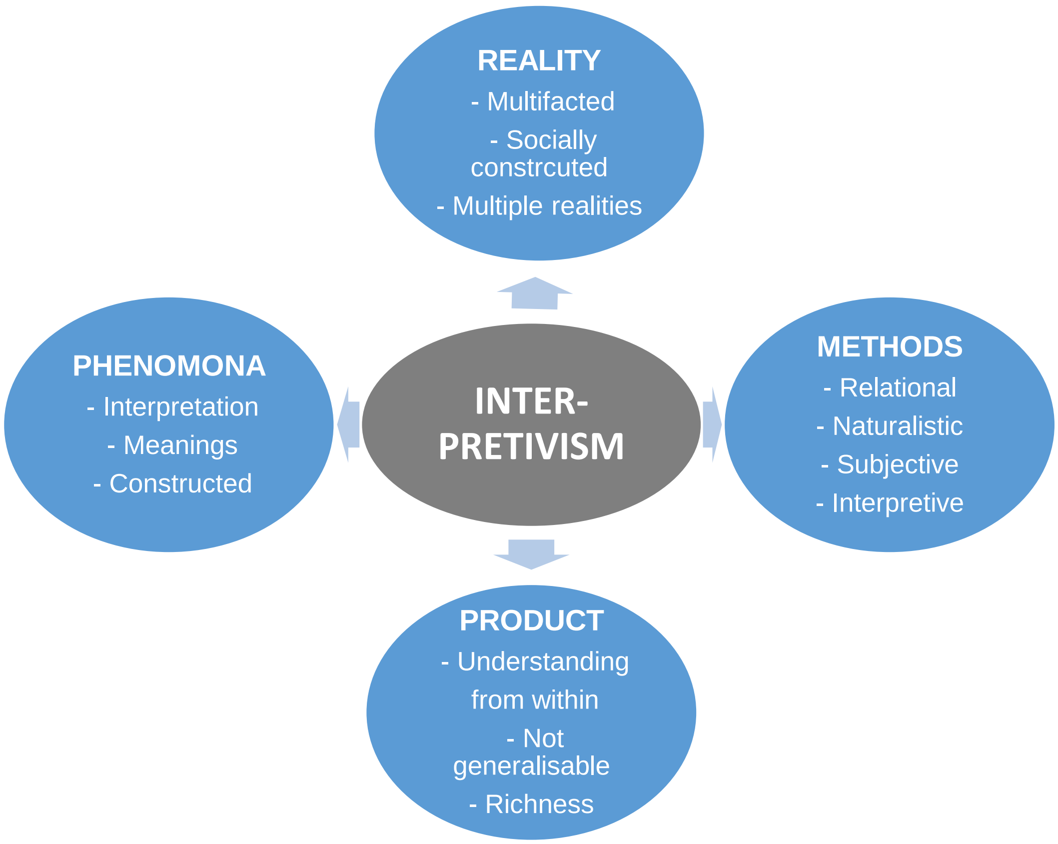


Figure 3-2: Main characteristics presented by an interpretivism philosophy (source: adapted from Maree, 2007)

As seen above in figure 3-2 the interpretivism focused on searching for understanding from within, constructing knowledge as data progress. The study investigated teachers' preference of the apps they select and use in teaching science for the FET phase. The study aimed to make an in-depth enquiry regarding the process educators follow to select these apps, constructing knowledge as you work through the process. However, one would not be able to quantify the teachers' understanding and therefore the interpretative paradigm would be best suited to this study

(Morgan, 1980). Interpretive research focuses on the complexity to make sense of human understanding as a specific situation emerges (Kaplan & Maxwell, 1994).

3.3.2 Approach: Qualitative research

Quantitative and qualitative approaches consist of and make use of different methodologies that contribute to the argument (Gelo, 2008; Burns & Bush, 2010 & Struwig & Stead, 2007).

It is important to note that qualitative and quantitative research approaches differ in numerous ways because of their individual characteristics according to Burns and Bush (2010), although Dreyer (1998) argues that the one approach can improve and complement the other approach during the research process. Quantitative and qualitative approaches both have their distinct strengths and weaknesses (Creswell, 2014) and it can be argued that a mix of both can have a positive effect on the outcome of the research analysis (Kent, 2007).

Qualitative research aims to address the breadth of attitude, opinion or belief and does not necessarily describe a single research method, therefore the main focus is to analyse in depth (Bradley, 2007). According to Struwig and Stead (2007), qualitative research reflects a great variety of research methods and the emphasis is on describing, giving meaning and understanding what is being studied which leads the researcher to believe that qualitative research methods are less concerned with collecting numerical data albeit numerical data may be generated and employed during analysis. (Bradley, 2007).

Quantitative research can be described as a form of conclusive research and is dedicated to describing the quantity of some feature of a data set of research data cluster (Gelo *et al.,* 2008). According to Struwig and Stead (2007), quantitative data generally refer to numerical data and are centred on the allocation of numbers to the objects of study, which means that it lends itself towards statistical analyses. The main differences between a quantitative and qualitative approach can be seen in table 3-2 below.

Table 3-2: Quantitative and qualitative research methods compared (source: adapted from Gelo, Burns & Bush, 2008; Becker, 1996)

Criteria	Quantitative research methods	Qualitative research methods
Focus of the research	Quantity - investigating how many offer the same data	Quality - investigating the nature and essence of the concept
Sampling methods	• Random samples • Single random sample • Systematic random sample • Stratified random sample • Grouped sample • Purposeful sample • Convenience sample	• Purposeful samples • Convenience sample • Homogeneous case sample • Extreme and typical case sample
Data collection methods	• Tests or standardised questionnaire • Structured interviews • Closed observation protocol • Census Secondary data • Official documents	• Interviews • Focus groups • Natural observation protocol • Secondary data • Official documents; personal documents
Data Analysis	• Descriptive statistics • Inferential statistics	• Descriptive/narrative • Identifying of categories/themes • Association between categories/themes
Data interpretation	• Generalising and forecasting (theory-driven) Interpretation of a theory	• Contextualisation Interpretation based (data driven) personal interpretation

As seen above in table 3-2 different sampling methods, data-collecting methods, data-analysis and data-interpretation methods would guide the researcher to determine whether a qualitative or quantitative approach to the research would be followed.

Cahill (1996) argues that the use of a qualitative research method boosts the internalisation of the results, helping the researcher to implement the findings. In qualitative research the researcher is considered an instrument of data collection and analysis, the researcher engages with people, situations and makes multiple interpretations (Mayring, 2000). This can be seen as an advantage or if not appropriately administered, a shortcoming. According to Saunders *et al*. (2000), the researcher must therefore aim to collect data in a non-interfering manner in the real-life scenario without pre-set restrictions or conditions that could influence the study. The researcher must continually state their personal motivation, interest or perspectives in the report, to eliminate a biased conclusion (McCaslin & Scott, 2003). Other disadvantages to take into account are that the researcher can affect the design of the study, the study group may not be representative of the larger population, observations may be biased and data collection is affected by the presence of the researcher as explained by the Heisenburg Uncertainty Principle (Becker, 1996; McCaslin & Scott, 2003; Ponterotto, 2006).

It is argued by Mayring (2000) and Guba (as cited in Struwig & Stead, 2001) that human learning is best researched by means of a qualitative study. This study is about human learning and the selection and use of apps as an effective resource in facilitating optimum education. For the purpose of this study, qualitative research would enhance the possibility for some kind of objectivity which would have been lost if any other method were applied (Ponterotto, 2006). The research approach is therefore qualitative rather than quantitative; because it aims to clarify the multiple realities presented in the data and would best suit an interpretivist research philosophy (Maree, 2007).

3.3.3 Motivation for choosing a qualitative research design

According to Burns and Bush (2010), qualitative research can be employed for research that looks deeply into a specific complicated situation and processes and for research on little known phenomena or innovations where the research needs to explore the 'where' and the 'why' of relevant variables.

It can therefore be argued that qualitative research is used when the researchers lack a clear idea of the problems being researched, when important variables may be unknown and when in-depth background information is needed in order to build theories (Burns & Bush, 2010). To motivate the suitability of a qualitative research design for this study, it is important to recognise the advantages and disadvantages of using this kind of research design, as seen in table 3-3 below.

Table 3-3: Advantages and disadvantages of a qualitative research design (source: adapted from Creswell, 2014, Kumar, 2005; Hair, Bush & Ortinau, 2006)

Advantages	Disadvantages
Natural setting: Respondents are observed and viewed in their natural surroundings without the presence of artificial behaviour that many times presents itself with quantitative research.	**Sample size:** Oftentimes research draws a too small sample to allow the researcher to generalise the data beyond the sample selected for the research study.
Depth of research: It allows the researcher to intensify the depth of understanding of the issue investigated i.e. gathering rich data.	**Reliability of data:** Loss of objectivity might be a problem because of the fact that single observers are usually describing a unique event and researchers are in close contact with participants.
Flexibility: It is flexible and allows the researcher to practise new ideas of concern.	

3.3.4 Strategy: Collective case study

A case study is clarified by Bromley (1991), Creswell (2014) and Yin (1994) as a systematic approach to explaining and understanding a phenomenon, interest or event. It can therefore be argued that a case study is to be used as a research strategy to investigate situations in a real-life context (Maree, 2007). Creswell (2013) states that the researcher seeks to understand by investigating single or multiple cases over time using numerous sources to excerpt information. Case studies are used to investigate social phenomena in their natural setting (Yin, 1994).

Case studies are defined according to Creswell (2014) in terms of the following criteria:

1. Group size: does the case require an individual, group or community to be involved; and
2. Intent of the case:

    - Instrumental case study: a single issue or concern is highlighted and investigated.
    - Collective case study: one issue is selected and multiple case studies are used to illustrate the issue. Multiple programmes from one case or various research sites might be used, normally replicating the procedure in various cases.
    - Intrinsic case study: where unusual or unique situations are investigated.

During this study, a collective case study was selected to investigate the selection and use of apps. Multiple case studies were used to replicate the procedure and investigate the findings. The researcher chose to observe three educators in their everyday life and investigate how they use resources to enhance their teaching; therefore it can be said that each teacher was seen as a separate case and the issue investigated was replicated in each case. The three case studies were selected due to the following criteria (*cf.* Section 3.6):

- A secondary school;
- The school setting, either rural, urban or private;
- Schools using electronic resources; and
- Science educators using apps in their science lessons.

Table 3-4 below demonstrates how the three selected schools met the criteria used to select the cases.

Table 3-4 Selection criteria (source: The Researcher)

	School	A	B	C
Criteria A	Secondary school	√	√	√
	Electronic resources used by teachers	√	√	√
	Science educators uses apps in science teaching	√	√	√
Criteria B	Rural setting (DofE)			√
	Urban setting (DofE private)		√	
	Urban setting (IEB private examination board)	√		

As seen in table 3-4 above the researcher selected three educators as three individual case studies. The three cases (or educators) were selected due to the context of the school: One private school, one from an urban school and one rural school. All three cases selected had to meet the criteria as set out by table 3-4 above. All three cases should have been using mobile tablets to enhance teaching, educators should be using apps to assist with science teaching and lastly participants selected should be qualified secondary school educators.

The researcher decided to investigate educators in secondary schools to ensure that the results would be comparable. Three educators provided an in-depth study of one issue replicated in three settings, as described by Creswell (2013) in collective case studies. The schools were selected one from each setting:

- Urban setting, private curriculum: one private school following the IEB curriculum
- Urban setting, Department of Education (DofE) curriculum: one private school following the DofE curriculum,
- Rural setting: one Model C school following the DofE curriculum.

The conclusions from each case study are compared and used to draw the final conclusion (Creswell, 2014).

Case studies are also used to answer ‘how’ and ‘why’ questions when a control is not required (Maree, 2007; Yin, 2003). One advantage of using a case study strategy is that the research makes use of multiple sources and various data-gathering instruments, making it more reliable (Maree, 2007; Yin, 1994). In this study various data-gathering instruments are employed to ensure reliability, namely semi-structured interviews, structured classroom observations and questionnaires. The results from the three instruments would be used to compare and validate the findings. Several guidelines are available for conducting case study research (Stake, 2005; Creswell, 2014; Yin, 2003); however, the six steps proposed by Stake (2005) for conducting case study research were employed:

- **Determine and define the research question**: A well-grounded study focuses correctly and should guide the research at all times. The research question has been formulated to address the issue of how educators select and use apps in science education (*cf*. Section 3.2). The focus determines whether a case study is an appropriate approach to the research problem. A case study approach was selected for this study to assist with the in-depth understanding of the process educators follow to select and use apps in science teaching.
- **Select the case and determine the data gathering and analysis techniques:** When using multiple cases, each case is treated as a single case study and the conclusion from each case are used to contribute to the whole study. Due to the nature of the study, various factors are available for research and purposeful sampling are employed to select cases that show different perspectives on the problem investigated. Participants were selected from three different school settings, one from a rural school, urban school and private school.
- **Prepare to collect the data:** Data collection in case study research is drawn from a variety of sources. Semi-structured interviews, observations and questionnaires were used to collect data from the three cases.

- **Collect data in the field:** Data collected from the multiple cases were organised to ensure patterns are uncovered.

Evaluate and analyse the data: The case study method with its multiple data-collection and analysis techniques provides the researcher with information to triangulate the data and support the research findings.

- **Prepare reports:** The researcher reports on the case studies in a manner that ensures the multi-faceted issue can be interpreted independently by the readers.

3.4 RESEARCH PROCESS

Maree (2007) and Gelo *et al.* (2008) state that during a qualitative study data collection and data analyses are treated as one uninterrupted process, rather than two separate processes, as seen below in figure 3-3.

Figure 3-3: Research process (source: Maree, 2007; Gelo, Burns & Bush, 2008)

The research process as illustrated above in figure 3-3 above involves a continuous interaction between the data collected and the gaps identified in the data; as well as a link between the researcher reflecting on the collected data and the plans for further investigation. This process occurs continually and forms the cyclical process of data collection, reflection and analysis. To ensure that the objective of the study is ultimately reached, a step-by-step research process plan was used, as illustrated in figure 3-4 below:

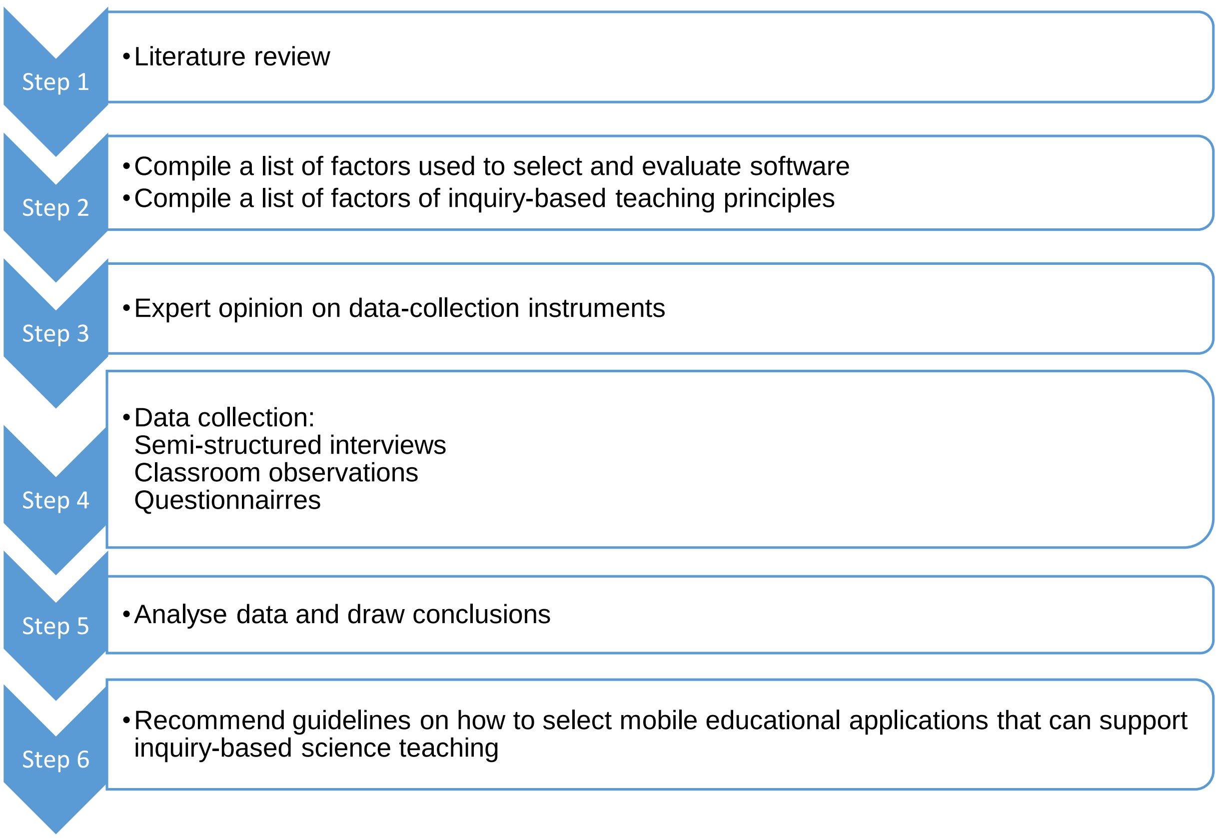


Figure 3-4: Step-by-step research process (source: The Researcher)

As seen above in figure 3-4, firstly literature was examined to draw on the possible ‘factors’ considered by experts to evaluate software and resources and identify the ‘principles’ of inquiry-based teaching. The data-collection instruments were designed with these ‘factors’ and ‘principles’ in mind and the input of subject experts. The researcher conducted the research and collected data using semi-structured interviews, observations and questionnaires. After the collection of data, the raw data were analysed and a conclusion drawn based on the information represented by the data. Lastly a set of guidelines was proposed that could support science teaching with the help of the inquiry-based teaching style.

3.5 THEORETICAL FRAMEWORK

A theoretical framework is a set of concepts used to guide research (Willis, 2007). To clearly plan the research undertaken, it is recommended to construct a conceptual framework which will simplify the research task and provide direction in the field of study (Fisher *et al.,* 2004). Saunders *et al.* (2003) suggest that a framework is also used to direct the analysis of the data in an efficient way.

The conceptual framework used to direct this study is based on the theoretical technological pedagogical and content knowledge framework (TPACK) by Koehler and Mishra (2009) as discussed in chapter 2 (*cf.* Section 2.4).

As discussed in chapter 2, the model represents the three main components of teachers' knowledge: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK) as well as the essential interaction between the three components as seen in figure 3-5 below (Koehler & Mishra, 2009).

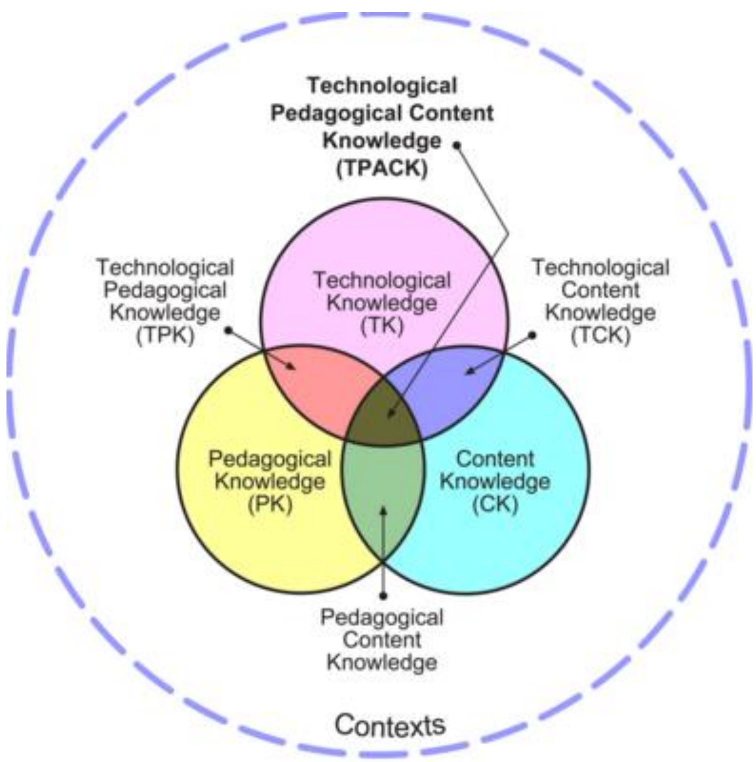


FIGURE 3-5: TPACK framework and its knowledge components (source: Koehler & Mishra, 2009)

As seen above in figure 3-5, the interactions between the three main components are represented as technological pedagogical knowledge (TPK), technological content knowledge (TCK) and pedagogical content knowledge (PCK). During this study only the pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and context were investigated as illustrated in table 3-5 below (*cf*. Figure 3-8) . The content knowledge (CK), pedagogical knowledge (PK), technology knowledge (TK) and technological pedagogical content knowledge (TPACK) were considered and taken into account but not investigated as explained below in table 3-5.

*Table 3-5: Application of the theoretical framework implemented in this study (*Koehler & Mishra, 2009; **Source: The Researcher)*

Knowledge component(*):	Description(*):	Applied to the study(**):
Content Knowledge (CK)	Knowledge of the subject matter.	Not applied, however only qualified and experienced educators were selected (*cf.* Section 3.6).
Pedagogical Knowledge (PK)	Knowledge about teaching methods and styles that best support the relevant subject.	Not applied, however a literature study was conducted to find the best teaching style to support science teaching (*cf.* Section 2.2.7).
Technology Knowledge (TK)	Knowledge of technological principles and methods to apply these tools and resources.	Not applied, however participants were selected on account of the fact that they were using apps as supporting tools (*cf.* Section 3.6).
Pedagogical Content Knowledge (PCK)	Knowledge of the link between curriculum, assessment and pedagogy.	Knowledge of the link between the content taught from the South African science curriculum and how the principles of inquiry-based teaching can support the subject.
Technological Content Knowledge (TCK)	Knowledge of how technology can support their subjects' content.	Knowledge of how apps can support science teaching in the FET phase.
Technological Pedagogical Knowledge (TPK)	Knowledge of how technology can change or enhance the teaching and learning process.	Knowledge of how apps can support the principles of inquiry-based teaching.
Technological Pedagogical Content Knowledge (TPACK	Knowledge of effective teaching with technology incorporating all components from the framework to ultimately have meaningful and expert teaching with technology	All factors were taken into account either when selecting the participants for the study (during CK, TK and PK) or when conducting research with the help of interviews, observations and questionnaire (during PCK, TCK and TPK).
Context	The context where the TPACK framework is applied.	Each case study presented a different context, in which the researcher conducted the case study. These differences ultimately give deeper understanding to the comparison drawn between cases (*cf.* Section 3.3.4).

As seen above in table 3-5, each knowledge component adapted from the TPACK framework proposed by Koehler and Mishra (2009) refers to a specific knowledge field, how these apply to the study is explained below:

- Content Knowledge (CK): educators' knowledge of the subject matter. This component of the framework was not included in the current study, as the researcher felt that if would be a tough task to measure the educators' content knowledge. The researcher selected experienced and qualified educators and assumed that these educators had a good understanding of the subject matter that they teach at the FET phase (*cf*. Section 2.4.1).
- Pedagogical Knowledge (PK): educators' knowledge about teaching methods and styles that best support their subject. The researcher did not test teachers' knowledge of various teaching styles, but identified through the literature review the recommended teaching style to teach science. A clear explanation of inquiry-based as a teaching style is given in chapter 2 (*cf*. Chapter 2).
- Technology Knowledge (TK): an educator's knowledge of technological principles and methods to apply these tools and resources. The researcher didn't test the participants' knowledge of technological principles or skills to use these tools. The participants were selected only if they had already been using apps for a while to support their teaching (*cf.* Section 3.8).
- Pedagogical Content Knowledge (PCK): the link between curriculum, assessment and pedagogy. Educators were asked about their awareness of inquiry-based teaching to support scientific education and how they employed their knowledge of both fields during their lessons.
- Technological Content Knowledge (TCK): an educator's knowledge of how technology can support their subjects' content. Educators were asked to express how they employ apps to support their subject. Educators were also observed to understand how these tools were employed during their teaching.
- Technological Pedagogical Knowledge (TPK): an educators understanding how technology can change the teaching and learning process. During the observations the researcher identified ways that apps were used to support and encourage inquiry-based teaching. To verify the findings the participants were also asked to verify how they have used the tools to support the principles of inquiry-based teaching.
- Technological Pedagogical Content Knowledge (TPACK): the educators' knowledge of effective teaching with technology incorporating all components from the framework to

ultimately have meaningful and expert teaching with technology. A comparison between all three knowledge components were drawn.

- Context: three case studies were conducted, with each case being selected in terms of the different context offered (cf. Chapter 3).

3.6 POPULATION AND SAMPLING

Population is described by Struwig and Stead (2001) as the entire aggregation of elements from which a sample is to be selected. The population for this study was all science educators who use apps as resources in their classrooms.

Sampling is divided by scientists into two sets, the non-probability and probability sampling methods, where the non-probability sampling relies on the discretion of the researcher (Tustin *et al*., 2005). During non-probability sampling it is argued that the population is evenly represented and the results drawn can therefore be more accurate (Maree, 2007). This study was conducted in the context of the interpretative paradigm, using the case study method, making use of a non-probability sampling, where participants were purposeful selected and descriptive comments are drawn from the sample (Guarte & Barrios, 2006). Participants had to meet certain criteria in order to be selected.

The sample strategy for this study was a purposive sample. The participants were chosen because they met the criteria set out by the researcher (Struwig & Stead, 2001). The sample size according to Luborsky and Rubinstein (1995) depends on the nature of the study, however, this study focused on a smaller sample so that the researcher can concentrate in depth on the participants views and use this to draw the required guidelines, according to Guarte and Barrios (2006), also very few teachers met the criteria set out by the researcher (see below) when the study was conducted. Only a handful of schools were employing apps during their lessons and even fewer were applying these tools to their lessons.

The sample for this study was selected on the basis of the following criteria:

- Qualified science educators
- Educators with more than two years' teaching experience
- Educators using apps as a teaching resource
- Educators using apps during FET-phase science lessons
- Educators who have selected apps for their science classroom

The group of three cases, the three science educators within their respective setting, which abide to the abovementioned criteria were selected as follows: one from a private school using the IEB curriculum in the Gauteng region, one from an urban school using the DofE curriculum in the Gauteng region and one from a rural school using the DofE curriculum in the Eastern Cape region. The participation was voluntary but the sample was predefined in terms of their qualifications and occupations, therefore it can be argued that a quota sample was being used (Tustin *et al.,* 2005).

3.7 DATA COLLECTION

Figure 3-6: The adapted research onion (adapted from Saunders, Lewis & Thornhill, 2015)

It is also argued that by using more than one data-collection source the interpretations are seen from various points and are more reliable (Maree, 2007). Various data-collection methods were employed as seen above in figure 3-6 to ensure a 'thick description' of the data collected

(Creswell, 1994). During this study the following data instruments were used to answer the research questions as seen below in table 3-6.

Table 3-6: Research questions addressed by the instruments (source: The Researcher)

Research question	Data instrument			
	Literature review	Interview	Observation	Questionnaire
Main research question: *How do the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?*	Hope to answer: How do the selection and use of educational resources support inquiry-based teaching in the FET phase?	X	X	X
SQ1: What determines the preferred selection of specific mobile educational applications for science teachers?	Hope to answer: What determines the preferred selection of educational resources for science teachers?	X		X
SQ2: How can the use of these mobile educational applications support inquiry-based teaching?		X	Hope to observe the use of apps in an inquiry-based science lesson.	
SQ3: How can mobile educational applications support inquiry-based teaching in science in a rural and urban contexts in South Africa?		X	Hope to observe the use of apps to support inquiry-based teaching in rural as well as urban schools.	

During this study three instruments were used, as seen in table 3-7 below, to seek the factors employed to select apps. These factors were used to develop guidelines to select apps that would support inquiry-based science teaching in the FET phase.

Table 3-7: Research instruments (source: The Researcher)

Data-collection technique	**Documentation method**	**Aim**
Literature review (*cf.* Chapter 2)	Background reading to identify and summarise principles and factors.	Identify possible principles or factors of selecting resources and group principles of inquiry-based teaching (*cf.* Table 2-3).
Semi-structured interviews (*cf.* Section 3.7.2)	Recordings and transcriptions.	Draw up a list of factors used by educators to select apps for the use in science teaching *(cf.* Section 2.2.9).
Observations (*cf.* Section 3.7.3)	Making field notes and transcriptions.	Observe how educators are using the selected apps, possibly in an inquiry-based science lesson (*cf*. Section 4.3).
Questionnaires (*cf*. Section 3.7.4)	Preconfigured forms filled in by participants.	Confirm the guidelines identified (*cf*. Section 6.2 and Table 6-1.

In the section to follow each instrument used for this study, as seen above in table 3-7, are discussed and warranted.

3.7.1 Data-collection process

The researcher used the following process, as illustrated in figure 3-7 below, to substantiate data drawn in aid of forming a conclusion.

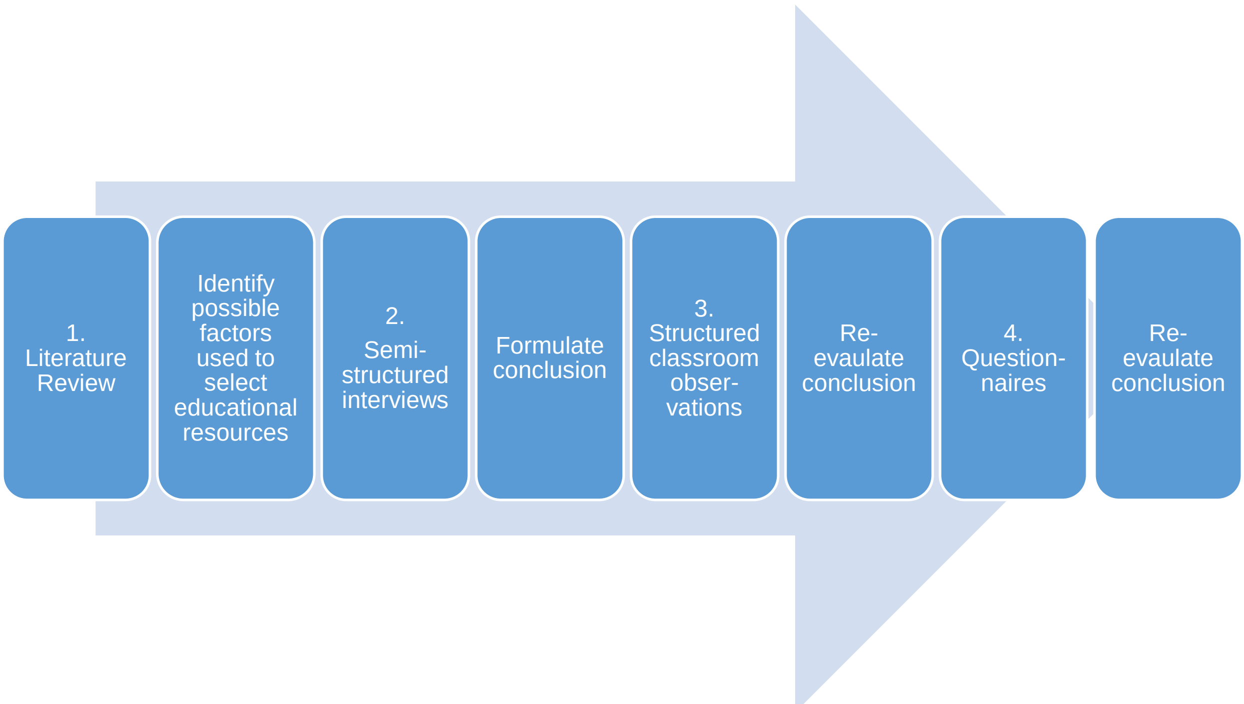


Figure 3-7: Process to substantiate data (source: The Researcher)

The researcher used the data-collection process as seen above in figure 3-7 to ensure that the factors are narrowed down after each instrument used. The literature provided background on how teachers select educational resources to assist science teaching, the data gathered had been used to identify 'factors' to investigate and verify as possible guidelines to use when selecting apps to support inquiry-based teaching. These factors identified from the literature review (*cf*. Table 2.2) were used to assist with the data-collection instruments. After each section of the data collection process these factors identified would be reviewed to ultimately create a well triangulated guideline to select apps for science teaching that would support inquiry-based teaching.

3.7.2 Semi-structured interviews

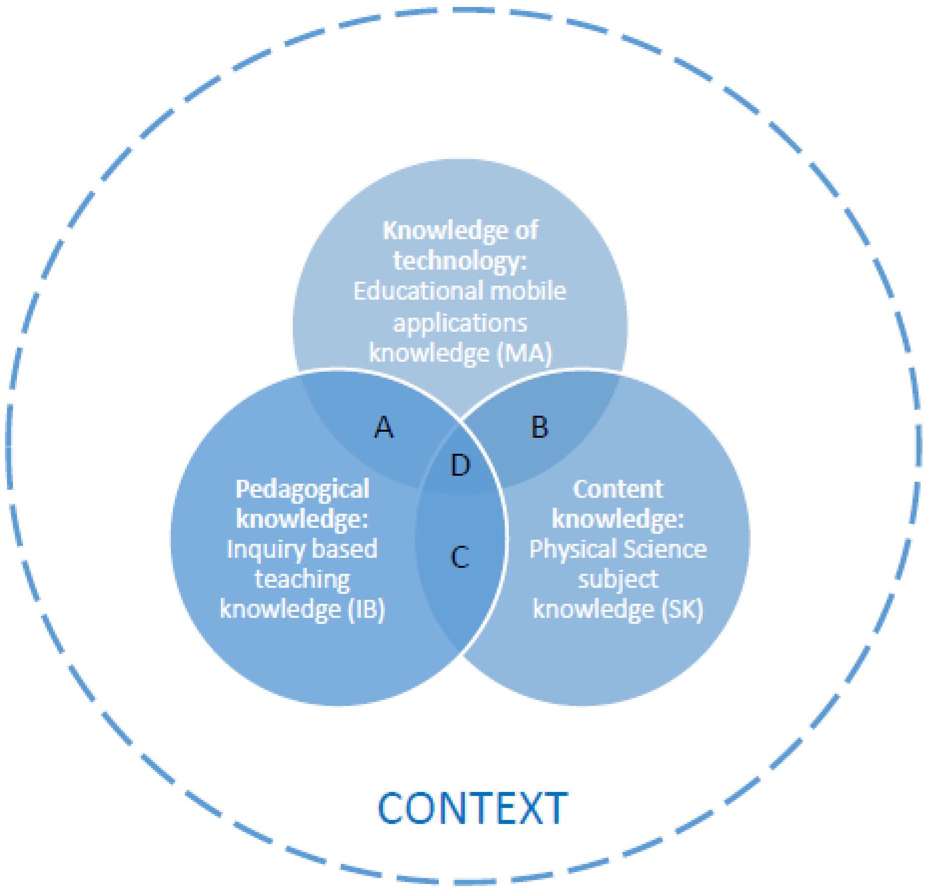
A semi-structured interview is a data-collection technique that involves the oral questioning of participants, in a two-way conversation, either as individuals or as a group where the researcher seeks to understand the participants' ideas, beliefs, views and opinions (Condie, 2012; Maree, 2007; Driskell *et al*., 2013).

Semi-structured interviews do allow for 'probing', a process where the researchers can verify their understanding of the presented data (Qu & Dumay, 2011; Driskell *et al*., 2013). Three probing strategies can be used, according to Maree (2007):

- Detail-oriented probes: to ensure that the researcher understands the detail provided by the participant.
- Elaboration probes: asking the participant to elaborate on a certain scenario.
- Clarification probes: used to check that you have accurately understood and noted the participant's response.

Semi-structured interviews pre-empted the classroom observations that took place during this study. Teachers were interviewed on and probed regarding the selection process of apps they use in class.

The researcher asked questions to ultimately reach an understanding of the process followed by educators to select and use apps in science. As seen in figure 3-8 below, the researcher aimed to ask questions to gain an understanding about all three components of the TPACK framework (adapted from Koehler & Mishra, 2009).



A: Interaction between educational mobile apps and inquiry-based teaching

B: Interaction between educational mobile apps and physical science

C: Interaction between physical science and inquiry-based teaching

D: Interaction between all components: educational mobile applications, Physical science and inquiry-based teaching in the specific context

Figure 3-8: Adapted TPACK Framework for this study (adapted from: Koehler & Mishra, 2009)

Figure 3-8 shows how the TPACK frameworks were adapted to suit the study. The three components of the TPACK framework, as seen above in figure 3-8, should all be considered to find the ideal teaching conditions where apps are selected in such a manner that it supports inquiry-based teaching in physical science. All three components should complement each other to ensure optimum learning is taking place. As mentioned in table 3-5 the study did not investigate or measure the educators' content knowledge (SK), pedagogical knowledge (IB) and technological knowledge (MA). These factors were merely addressed by selecting qualified educators (SK), identifying the best teaching style to support science teaching through the literature review (IB) and selected educators were using apps as supporting tools to teach science (MA). This study only looked at the interaction between the components and the questions asked were directed at the interactions between these components.

The following questions, as seen below in table 3-8, were asked to address each component individually or the relationships among various components (technology knowledge component, pedagogical knowledge component and content knowledge component), seen above in figure 3-8 of the TPACK framework. The interview questions are attached in Appendix A.

Table 3-8: Questions asked to address components of the TPACK framework (source: The Researcher)

Research question	**Knowledge component addressed**	**Semi-structured interview questions used to address the research questions**
Main question: How does the selection and use of mobile educational applications support inquiry-based teaching in Physical Science in the FET phase?	D: Overlap of knowledge of technology, knowledge of content and pedagogical knowledge (*cf.* Figure 3-8).	Question 2: Have using apps enhanced your lessons in any way? If so, how? Question 9: Which mobile educational applications (apps) do you use? Question 10: How often do you use the above mentioned (from question 9) app/s? Question 11: Why do you use the specific app/s? Question 12: How do you use the app/s to support your lessons?
SQ1: What determines the preferred selection of specific mobile educational applications for Physical Science teachers?	B: Overlap of knowledge of technology and knowledge of content (*cf.* Figure 3-8).	Question 1: How long have you been using apps as part of your science lessons? Question 4: Do you use a tablet or iPad? And why the specific device? Question 5: Who decided which (device) should be used? Question 15: Who decides which apps are used in the lessons? Question 16: How is it decided which app/s to use?

SQ2. How can the use of these mobile educational applications support inquiry-based teaching?	A: Overlap of pedagogical knowledge and knowledge of technology (*cf.* Figure 3-8).	Question 3: Do you find that your learners experience your lessons different due to the use of apps? Explain. Question 6: Did you get trained on using the tablet or iPad? Question 7: If 'yes', also ask: 7.1. Who trained you? 7.2. What were you trained in? 7.3. When was the last training that you have attended or received? Question 18: Have you experienced any problems with using app/s in lessons? If so, is there someone who can assist you? Question 19: Are you aware of inquiry-based teaching as a teaching style? Question 20: If so (from question 19), do you use your knowledge of inquiry-based teaching when using apps? Question 21: Would you encourage other educators to also use apps as resources and why? Question 22: How is using apps in teaching different from using other resources?

SQ3. How can mobile educational applications support inquiry-based teaching in Physical Science in a rural and urban contexts in South Africa?	C: Overlap of pedagogical knowledge and knowledge of content (*cf.* Figure 3-8).	Question 8: How have your lesson planning changed due to the implementation of apps in your lesson? Question 13: Is there any app/s that you have decided not to use? And why? Question 14: Have you come across an app/s where the subject knowledge is incorrect? Question 17: What should be considered when designing educational apps for science? (For example colour, length etc.). Question 23: What don't you like about using tablet or iPads as resources? What do you wish could change?

During the semi-structured interview, questions 2, 9, 10, 11 and 12 were asked to find more data with regard to point D on the TPACK framework as seen in figure 3-8 above, the overlap of all the knowledge components.

Questions 1, 4, 5, 15 and 16 were asked to probe understanding of point B, technology content and content knowledge.

Questions 3, 6, 7, 18, 19, 20, 21 and 22 were asked for better understanding of pedagogical knowledge and knowledge of technology, point A.

Point C is addressed by questions 8, 13, 14, 17 and 23, the knowledge of pedagogy and the knowledge of content.

Semi-structured interviews are commonly used to substantiate the data drawn from other data sources (Qu & Dumay, 2011; Struwig & Stead, 2001; Condie, 2012). Interviews are used in qualitative research to collect rich data that will assist the researcher in understanding the participants' knowledge construction and social reality (Maree, 2007; Qu & Dumay, 2011).

The three main knowledge components: pedagogical knowledge, technological knowledge and content knowledge were catered for in the sampling process (*cf*. Section 3.5).

The order of data-collection methods was selected to verify the findings presented by the educators in the interviews. The observations were used to verify the findings presented by the educators in their interviews. The researcher wanted to make sure that the educators were implementing apps during their science lessons as described during the interview.

3.7.3 Observations

Observations are commonly used in education, where the researcher plans to collect data first-hand (Boddy, 2004; Boote & Mathews, 1999; Blanton *et al*., 2006). The researcher is perceived as the main observer according to Boote and Mathews (1999) in interpretation studies rather than a machine or model that would generally support a quantitative study best.

The observations took place in an overt fashion, a method where the educators are informed about the observations and may request access to the recordings afterwards (Boote & Mathews, 1999). It is argued by Blanton *et al*. (2006) that natural observations rather than contrived observations would support interpretative studies best, therefore the researcher observed the three selected educators in their classrooms when utilising apps as part of their science education. Each educator was observed during lessons as arranged by the educators. Structured observations were selected as the researcher looked at pre-determined categories of behaviour where the guidelines as identified by the semi-structured interviews with the three educators were utilised as checklist form to record and score actions and behaviour (Maree, 2007; Blanton *et al*., 2006). No comments on other matters were recorded.

The researcher looked at the following criteria and recorded the time and number of times the incident occurred, the criteria, as seen below in table 3-9, were observed to address the relationship between various components of the TPACK framework (*cf.* Figure 3-8). The observation schedule is attached as Appendix B.

Table 3-9: Factors investigated during the observations to address all three components of the TPACK framework (source: The Researcher)

Research question	**TPACK Knowledge component addressed (figure 3.8)**	**Observation factor**
Main question: How do the selection and use of mobile educational applications support inquiry-based teaching in Physical Science in the FET phase?	D: Overlap of knowledge of technology, knowledge of content and pedagogical knowledge (*cf.* Figure 3-8).	How apps are used. Role apps play during the lesson.
SQ1: What determines the preferred selection of specific mobile educational applications for Physical Science teachers?	B: Overlap of knowledge of technology and knowledge of content (*cf.* Figure 3-8).	Apps used without errors during the science lesson. Types of apps used during the science lesson.
SQ2. How can the use of these mobile educational applications support inquiry-based teaching?	A: Overlap of pedagogical knowledge and knowledge of technology (*cf.* Figure 3-8).	Types of apps used to support teaching. Apps used to support inquiry-based teaching.
SQ3. How can mobile educational applications support inquiry-based teaching in Physical Science in a rural and urban contexts in South Africa?	C: Overlap of pedagogical knowledge and knowledge of content (*cf.* Figure 3-8).	Types of apps used during the lesson. The occurrence of inquiry-based teaching. Apps used to support inquiry-based teaching.

The factors observed as seen above in table 3-9 above, aim to link the classroom observations to the interaction of the three main knowledge components. The three main components: pedagogical knowledge, technological knowledge and content knowledge were catered for in the sampling process (*cf*. Chapter 3).

As stated by Boddy (2004) and Maree (2007), observations are commonly used in research to substantiate data emerging from other sources, in this case the semi-structured interview and questionnaire. According to Blanton *et al*. (2006) there is no standard observation and only small samples can be collected, due to the time constraint; therefore it could be possible that the information collected from observations might not support the answers in the interview and questionnaire.

Observations were used to make running physical notes. The ways in which apps are manipulated in lessons were coded using the constant comparative method (Struwig & Stead, 2004). This method is used to find meaning from data that are identified and coded; therefore each unit of meaning was compared with other units and was placed in categories or sub-categories (Struwig & Stead, 2004). The selection of specific answers for categories is linked to the process used for selecting certain applications.

The observation technique aimed for the author to extract detailed, augmented information about how teachers use the chosen apps in their teaching and if any of these apps could possibly support the principles of inquiry-based teaching as a teaching strategy.

3.7.4 Questionnaires

Questionnaires as explained by Maree (2007) and Richardson (2004) refer to a set of questions and answers that is provided to the participants. A few simple guidelines must be followed to ensure that questionnaires are valid (Tustin, Ligthelm, Martins & Van Wyk, 2005):

- Questions must be concise; and
- Questions should be worded in a manner so that the target group would understand what is required

These 'answer-response' questionnaires could be presented in various ways; however, for this study the questionnaire was presented after the semi-structured interviews and structured classroom observations to verify the findings, therefore a scaled-response was used. Scaled-responses allowed for the data to be coded directly from the answers provided (Tustin *et al*., 2005). Table 3-10 below indicates how the questions asked during the questionnaire aims to answer the research questions.

The questions asked as seen in table 3-10 below, are mostly ranked or open-ended questions. According to Tustin *et al.* (2005) itemised rating scales are a graphic continuum that is provided to the participants, however the participants only select from a limited number of categories, the participants selected the most favourable attitude towards the concept investigated. The questionnaire is included in Appendix C.

The three main knowledge components: pedagogical knowledge, technological knowledge and content knowledge were catered for in the sampling process (*cf*. Section 2.4).

Table 3-10: Questionnaire questions linked to research questions (source: The Researcher)

Research question	**TPACK Knowledge component addressed (figure 3.8)**	**Questionnaire questions used to address the research questions**	**Response options**
Main question: How does the selection and use of mobile educational applications support inquiry-based teaching in Physical Science in the FET phase?	D: Overlap of knowledge of technology, knowledge of content and pedagogical knowledge (*cf.* Figure 3-8).	Question 4: Tell us about why you use apps in your lessons.	It is convenient, I am in control of the technology, it is familiar to me, it is a fashion statement, and it supports the students' understanding, learners' response and curriculum related.
		Question 6: How important is the following information for an app?	The information should be relevant, the information should be given in small sections, the information should be available to the learners as well, the information should be colourful, the information should be able to download to use later, the information should be cheap to access, the information should encourage learners to think for themselves, the information should pose questions with the learners, the information is current and up to date, the information should be South African, the information should be developed by educational specialists, the app must meet the requirements of all the learners in the class, the app should indicate for what age the information is appropriate and technical performance.
		Question 7.4: What would you change about apps used for education?	

SQ1: What determine the preferred selection of specific mobile educational applications for Physical Science teachers?	B: Overlap of knowledge of technology and knowledge of content (*cf.* Figure 3-8).	Question 1: How important do you consider the following aspects when you decide which app to download	Easy to use, cost, someone told me about the app/s, funky, new or desirable features, scientifically correct; and curriculum related.
		Question 8: Would you recommend to other educators to use apps when teaching science?	
		Question 10: How do apps support science education?	Students are more interested in Science, students grasp complex concepts better and I am more motivated to teach Science.
SQ2. How can the use of these mobile educational applications support inquiry-based teaching?	A: Overlap of pedagogical knowledge and knowledge of technology (*cf.* Figure 3-8).	Question 2: How skilled are you on electronic devices, especially your tablet/iPad?	
		Question 3: When using apps for a learning task, how important are the following in getting the job done?	My expectations, the times it takes, my skills level, my enjoyment, the learners enjoyment, my mood, the learners results; and previous success.
		Question 7.1: How is using apps for educational purposes different than	

		using apps for entertainment?	
		Question 7.2: What do you like about apps for educational purposes?	
		Question 7.3: What don't you like about apps for educational purposes?	
SQ3. How can mobile educational applications support inquiry-based teaching in Physical Science in a rural and urban contexts in South Africa?	C: Overlap of pedagogical knowledge and knowledge of content (*cf.* Figure 3-8).	Question 5: Tell us about how you use apps in your lessons	To draw learners' attention, to introduce a new concept, to demonstrate concepts and to keep lessons interesting.
		Question 9: How do apps enable you to do something you were unable to do in the past?	

3.7.5 Summary

The questions asked are linked to 'why' and 'how' teachers apply apps to teach science. This research process (*cf.* Section 3.7.1) was followed to ensure that data were verified as we progressed from one section to the next. The questionnaire provides a concise set of guidelines that teachers' use to select apps. The observation identified how apps are used in the educators' science lessons. The questionnaire responses were compared to the semi-structured interview and observation to ensure the data are well triangulated. The proposed guidelines that were identified during the semi-structured interviews and structured observations would be confirmed with the help of the questionnaire and presented as the conclusion or final product of the study.

3.8 DATA ANALYSIS

No statistical data were drawn from this study, but rather an on-going iterative or non-linear process was followed. Data collecting, processing, analysis and reporting are entangled according to Maree (2007) and therefore a qualitative approach was used to analyse the responses drawn from this study. Fade and Swift (2010) argue that the researcher is the main instrument of data analysis during qualitative research and that either a literal or inductive approach can be applied to the data analysis process.

3.8.1 Hermeneutic circle

The main goal of data analysis in an interpretive study is to produce an in-depth understanding of the context (Struwig & Stead, 2001). It is argued by Forsythe (1987) that the strength of analysis in the interpretative study lies in the interpretation of data and the explanations drawn. According to Klein and Myers (1999) the hermeneutics is one mode of analysis associated with interpretative research. The hermeneutics suggests a way of understanding the meaning of data or text correspondents (Klein & Myers, 1999).

Hermeneutics is another theory or viewpoint described as the 'art' of interpretation (Abulad, 2007), where the researchers and the participants must draw an understanding based on the interaction among all systems, where the hermeneutic circle evolves as a complex interaction of sharing (Klein & Myers, 1999). As interpretivism aims to see the world from the perspective of the world (Kelliher, 2005), it is understandable why Walshaw (1995) explains that hermeneutics and interpretivism are closely linked. Therefore, the interpretation process was also supported by the seven principles of interaction between the researcher and subjects as stated by Klein and Myers

(1999). The principles proposed by Klein and Myers (1999) were utilised to conduct and evaluate interpretative case studies are presented below in table 3-11.

Table 3-11: Principles for conducting and analysing interpretive research (adapted from Klein & Myers, 1999)

7 Principles for conducting and evaluating interpretative studies:	**How the principle is utilised in this study:**
1. The principle of the hermeneutic circle: This principle is the driving force of the process, as it will guide the application of the other principles. This principle seeks to find sense of individual elements and how they fit together as a whole. This refers to the process of data collection, where the interpretative researcher was seeking data that are ever changing and therefore a cyclical process that supports the data gathering process, as directed by the hermeneutic circle.	This principle was applied during chapter 4 and five, where the data were presented (*cf*. Section 4.3) and analysed (*cf.* Chapter 5). This principle was applied in part and whole using Creswell's (1994) case-study analysis template.
2. The principle of contextualisation: The researcher must embrace the social and historical differences to continually seek meaning in context of the data presented. Another vital point is to perform the research in the subject's context so the researcher can observe the data and how it is affected by all external components.	Contextualisation was applied in two parts during the data-collection process. Firstly each case study has its own social, historical and educational context in which the data were collected. Secondly each case participant also had their own unique context on the basis of which they were selected and therefore could contribute to the study in a different manner.
3. The principle of interaction between the researchers and the subjects: This principle requires the researcher to experience the social context of the subject. Due to the nature of the study, where data are gathered from people with the help of social interaction, careful	This principle was utilised when the researcher visited the three educators in their context. The researcher interacted with the educators in their milieu to aid understanding and assist with the data analysis. The researcher also observed the educators in their context of the school and subject to observe how they used apps during their teaching.

thought had to be given on how the data were socially constructed due to the interaction of the researcher and the participants.	
4. The principle of abstraction and generalisation: Theory plays a fundamental role in the interpretive research and is used to direct the thoughts of the researcher in a certain way, especially by using understanding in one phase to draw the prediction of the next phase. The requirement to apply a theory or concept that describes the nature of human understanding and social action is of crucial importance in this principle.	This principle was employed to direct thoughts of the researcher throughout the study. The researcher firstly conducted an in-depth literature review to identify factors about how teachers select educational resources and identify inquiry-based teaching principles. Secondly these factors were used to guide the researcher through the process to design the research instruments. The data collection process were used to collect data. After each instrument used the factors identified were revised and used to predict the next phase. As seen in chapter 2 the literature review was used to predict the questions asked in the interview. After the interview the identified factors were adjusted and again used to predict the observation schedule. Classroom observations ensured more adjustments in the identified factors and guided the questions asked in the questionnaire. The questionnaire finally provided a final adjusted set of factors that could be used as a guideline to select apps for science teaching to support inquiry-based teaching.
5. The principle of dialogical reasoning: This step requires that researchers alter their presumptions that they used as direction for the research design. The possible recognition of contradictions between the theoretical preconceptions guiding the design and the actual data collected.	The data analysis was supported by comparing the data found in literature. The data-collection process was guided by the theoretical data found in the literature. The researcher designed the research instruments accordingly. After each data-collection process the next phase was reviewed and re-evaluated.
6. The principle of multiple interpretations:	The literature study and the data collection process acknowledged possible guidelines that are used to select apps.

The possibility that participants could account for the same detail in different ways. This principle is not always evident during research, but must be accounted for.	
7. The principle of suspicion: The least descriptive principle in literature is the possibility that participants might be biased in some way, however this points out another issue of how the researcher could possibly prove this and it is argued that some researchers rather do not follow this principle in their work.	Multiple sources of data collection were employed in a specific manner to ensure the researcher found the true picture. To ensure the researcher were not biased or accounted for only half of the truth, three data collection instruments were used. Semi-structured interviews, observations and questionnaires were used. The semi-structured interviews were employed first to identify factors used by teachers to select apps in science teaching. The observations were used to aid the understanding of how apps are used and to ensure the true picture were gathered. The questionnaire were done last to aid triangulation and check if the teacher selected the same factors after their classroom observations. This was employed to ensure triangulation.

The principles as seen above in table 3-11 of the hermeneutics circle require the researcher to understand the situations in parts and as a whole to assign reasons to them (Miall & Miall, 2004). To assist the researcher with the task of making sense of data the researcher employed Creswell's (1994) template for case study analyses, namely within-case, cross-case and holistic-case analyses. The three steps according to Creswell (1994) are explained below and were all employed during this study:

- **Within-case analysis:** Themes are identified during case-study analysis by the researcher. In this study, the researcher searched for possible themes across the three educators, each as a single case study. Data drawn from the individual cases are all compiled together and used to shape the guidelines of selecting and using apps.

- **Cross-case analysis**: Multiple case studies are analysed and compared with each other, to identify relating themes that are alike. Themes are occurring only in one case would still be added to the guidelines but the structured observation and questionnaire will be investigated to justify the selection.
- **Holistic-case analysis:** The analysis involves the researcher examining the whole case to identify themes and provide further interpretations. Data from each case were compared individually and later one holistic comparison was drawn from the three cases.

3.8.2 Data coding

The main difference between an interpretative approach, also called the data-driven or open coding, and the literal approach is that the researcher ignores personal perceptions and fits the data into a predetermined coding frame, while in inductive coding the researcher will reflect on their influence on the data analysis and use the data to develop codes (Fade & Swift, 2010).

Responses from the semi-structured interviews and questionnaires were coded and categorised accordingly to highlight the characteristics of selected resources and guide the researcher to present a set of guidelines to select apps (*cf.* Table 5-2; Table 5-3 and Table 5-4). Coding enabled the researcher to retrieve and group data (Tustin *et al*., 2005; Robinson, 2013; Maree, 2007; Fade & Swift, 2010). Coding can occur as 'inductive coding', where no pre-set codes are determined and the data are used to reveal probable codes or 'a priori coding' where codes are developed before the data are collected (Maree 2007). It is argued by Seidel and Kelle (as cited by Maree,

2007) that coding can act as a method to present findings in a transparent manner and a tool to steer future investigation.

According to Struwig and Stead (2005) the eight-step process of coding and data analysis was followed to ensure a comprehensive analysis:

1 **Understand the whole:** Notes were made as the transcripts were read through.

2 **Using one document at a time:** One document was selected at a time and analysed while making notes in the margin. The researcher aimed to understand one document before attempting to draw a conclusion on the whole. Each case study was analysed and attempted to be fully understood before the whole investigation was revisited to draw a conclusion.

3 **Identify topics:** Identify codes from the documents and cluster unique topics together.

4 **Adjust codes on documents:** Return to the documents and add abbreviated codes to the data.

5 **Identify categories:** Identify the most applicable words to use as categories and indicate relativity.

6 **Finalise categories:** Alphabetically categorise the topics together.

7 **Assemble data:** Group all data with the relevant topic and perform a primary analysis.

8 **Uncategorised data:** Recode existing data.

During this study in which the researcher premised no predetermined codes the researcher used the interpretative approach and the above-mentioned steps to identify codes and analyse the data (Maree, 2007; Fade & Swift, 2010).

3.8.3 Trustworthiness

One of the ultimate goals of a researcher is to design a study that has a strong internal and external validity and reliability, with procedures that would decrease biases within the research (Thurmond, 2001; Jonsen & Jehn, 2009; Bekhet & Zauszniewski, 2012). Two ways to increase the validity, strength and interpretative potential of the study are, as explained by Thurmond (2001), to decrease investigators' biases and use methods involving triangulation. Triangulation refers to the method of using a combination of several research methodologies in one study in order to ensure confident results (Maree, 2007; Tustin *et al*., 2005; Bekhet & Zauszniewski, 2012 & Thurmond, 2001). It is argued that in qualitative research the researcher is the data-gathering instrument therefore although 'reliability and validity' may generally refer to quantitative research, 'credibility and trustworthiness' would be a main focus of qualitative research (Maree, 2007). Trustworthiness refers to the trust in the output, where the data collected are true and the argument drawn is strong (Mauthner & Doucet, 2003). Another author argues that the researcher should aim to address the trustworthiness of the study by employing the following principles (Shenton, 2004):

3.8.4 Credibility

To ensure internal validity by ensuring the instruments were measuring what the study aims to be investigating. To ensure the credibility of this study, the researcher focused on the following steps proposed by Shenton (2004) to ensure the credibility of the study:

- The adoption of the correct research methods.
- Familiarising oneself with the culture of the participants.
- Triangulating data by using more than one method to collect data.
- Methods to ensure the honesty of participants.
- Iterative questioning as a method to draw understanding from previously raised data.
- Frequent discussions between the researcher and her supervisors to ensure the research was on track.
- Member checks to ensure the researcher understood what was meant by the data provided.
- Examination of previous research findings.

3.8.5 Transferability

This is the ability to apply one study to other situations, and referred to as external validity. A rich description of the participants' background information was provided to allow for others to consider how the outcomes could be used in another setting. Therefore information regarding the following was described in detail:

- Organisations participating in the study.
- Any limitations identified.
- The number of participants participating in the study.
- The method, number and length of data collections utilised.

3.8.6 Dependability

This refers to the ability to show that if the research were to be repeated with the same conditions the same results would be obtained. To ensure the accuracy of the data collected, the researcher provided the following information:

- The proposed research design and the steps of implementation.
- Detailed descriptions of the methods employed for data gathering.
- Suggested recommendations.

3.8.7 Confirmability

Confirmability refers to the researcher's objectivity. Triangulations of methods and sources as well as reflexivity are methods that could be used to ensure trustworthiness.

The principles mentioned earlier by Shenton (2004) are confirmed by Struwig and Stead (2004), who state that interpretative validity can be obtained by asking participants to comment on the interpretations of the researcher after all the interviews had been completed. Maree (2007) agrees that data need to be verified to ensure that it is consistent even when it is obtained on different occasions or by different forms of sampling - in this research by means of semi-structured interviews, classroom observations and questionnaires. The researcher asked the participants to verify earlier gathered information and to confirm his or her understanding with the participants (Maree, 2007; Struwig & Stead, 2004).

3.8.8 Triangulation

Triangulation was employed to verify findings from independent measures. To ensure that the test had face validity, the questionnaires were compiled with the assistance of the supervisor and co-supervisors of this project, ensuring that the questions were relevant to the purpose and to ensure the questions were free from uncertainty in their wording. In this way, the aim was to get responses properly related to candidates' understanding of the chosen app.

Triangulation is explained by Maree (2007) and Stavros and Westberg (2009) as a fundamental technique to validate data through cross-verification from multiple sources. Another advantage of triangulation is the amount of data collected that could be analysed possible patterns can be identified (Thurmond, 2001; Stavros & Westberg, 2009). Various types of triangulation are proposed by Thurmond (2001) namely: data-source triangulation, investigator triangulation, theoretical triangulation and data-analysis triangulation. In this study, two of these types of triangulation were employed. Multiple data sources were used to collect data and multiple measures for data collection were employed. Creswell (as cited by Stavros & Westberg, 2009) refers to data triangulation as using various data sources that collects data at different time intervals, different sources or in different scenarios to increase the confidence, credibility and validity in the findings. During this study, data triangulation was employed through the use of semi-structured interviews, structured observations and questionnaires.

3.9 LIMITATIONS

Very few schools were using tablets and apps especially when the research was conducted. It limited the schools that could be selected to investigate. Only a few teachers use apps and even fewer used apps to support the teaching of science, and this limited the selection of participants.

3.10 ETHICAL CONSIDERATIONS

Williams (2000) states that ethical clearance refers to a number of national and internationally recognised principles that provide a researcher with guidelines on how to conduct research in an ethically approved manner.

The researcher applied for ethical clearance from the Faculty of Education's Ethical Committee. Consent was obtained from the headmasters from the two Independent Education Board schools and from the headmaster from the DBE of Eastern Cape School (*cf.* Appendix 10.1.1). Informed consent was also obtained from the individual participants with regard to participation and presenting of data in any publications (*cf.* Appendix 10.1.2).

The CSIR has already obtained ethical clearance for the Tech4RED project from the Department of Education in the Eastern Cape and is in the process of applying to their internal ethical board for clearance to commence research.

In conjunction with the University of Pretoria's code of ethics the researcher paid attention to five aspects, namely:

- Social responsibility: the researcher was sensitive to participants and the greater community.
- Justice: all participants were treated with respect and participants kept anonymous. All information shared with the researcher was handled as confidential.
- Benevolence: we did not anticipate any risk in participating in this study, instead we foresee that the results will increase our understanding in the process followed to select mobile educational applications.
- Respect for the individual: the participation in this study was voluntary and the participants were free to withdraw from the study at any time. All information shared with the researcher will be kept by the University of Pretoria and the researcher for fifteen years. The participants have access to the data collection and final report written. All information will be handled as confidential and anonymous.
- Professionalism: the researcher conducted research in a responsible and professional manner. All the results and data collected from this research were made available to the participants to ensure reliability and integrity form the writer. The objectivity was addressed by not using any friends or colleague of the researcher during this study.

3.11 CONCLUSION

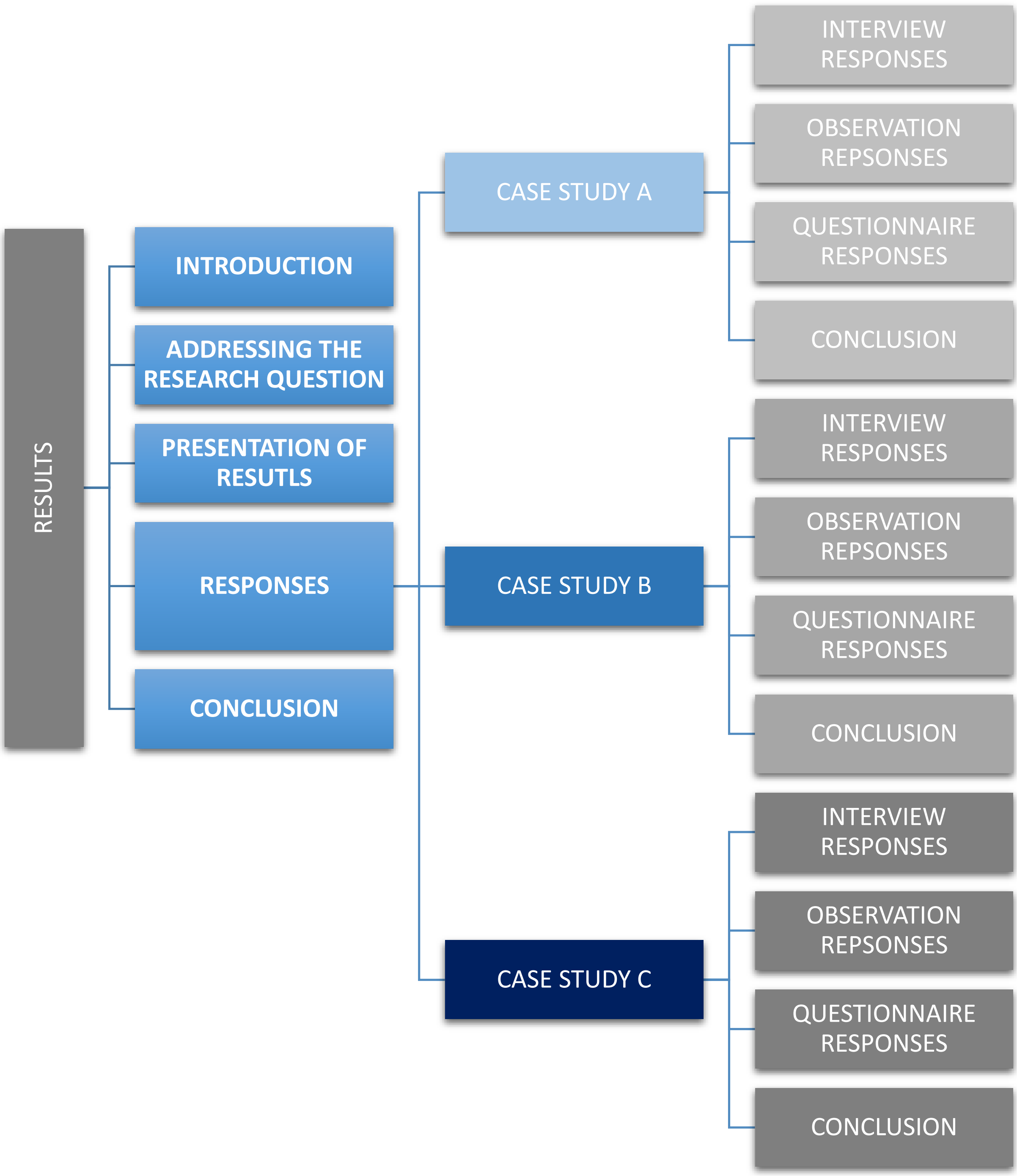
Chapter 3 discusses the philosophical assumption of the study. The researcher opted for the interpretive philosophical assumption because the research aims to investigate the selection procedure when selecting apps to use in Physical Science education.

More so, the research design is a qualitative research design employing a case study approach to achieve the research objectives. The research method was defined providing all the relevant steps to identify the guidelines for app selection.

This chapter ultimately highlights how the participants were purposefully selected from schools to achieve the research objectives. The methods of collecting data from the participants are described as interviews, classroom observations and questionnaires. This chapter explains how the data analysis was carried out and the measures followed to ensure trustworthiness of the study. The next chapter, chapter 4, discusses the results collected.

4. CHAPTER 4: RESULTS

Map of Chapter 4: RESULTS



4.1 INTRODUCTION

In chapter 3 the philosophical assumptions of the study were investigated followed by an explanation of the research design as well as the research methods. Chapter 3 aims to explain the sampling strategy and how the participants were purposefully selected from the chosen schools to achieve the research objectives of the study.

Chapter 4 elaborates on the results collected. Each case study is discussed separately and later in chapter five a comparison is made between cases to come to support the findings.

4.2 ADDRESSING THE RESEARCH QUESTIONS

The study thus far has provided a preliminary overview from current research and literature by other authors as a first step towards answering the research questions. Although the three case studies aim to answer the research sub-questions, the main question will be answered by ultimately comparing the empirical findings with the earlier literature review.

Careful analysis of the empirical data was therefore conducted by the researcher which included data collected form the teachers' interviews, written descriptions of teachers' lessons and the results provided from the questionnaires. Each school were presented individually (*cf.* Chapter 4) before a comparison took place between the three cases (*cf.* Section 5.4) and the findings that emerged from the literature review (*cf.* Table 6-1).

4.3 PRESENTATION OF RESULTS

As discussed in the previous chapters, the researcher conducted in-depth interviews (*cf*. Appendix A) with each participant in the sample. An observation of the classroom (*cf*. Appendix B) was conducted and the completion of a questionnaire (*cf.* Appendix C) served as the final step in the data-collection process. In the following section each case is discussed individually followed by Chapter Five which presents the comparison between the three cases and conclusion from the data collected.

4.4 RESPONSES – CASE STUDY A

4.4.1 Background

The first case to be considered (Case study A) presents itself as a private school in a medium-to-high income suburban setting writing the Independent Examinations Board (IEB) examination every year. Traditionally, teachers are well-qualified when joining the staff base and boasts numerous years of teaching experience in their field of expertise. In the rare occurrence that young teachers may lack any of the above qualities, a strong support system and good resources to develop their professional career is at arm's length. All learners at School A are encouraged to use an electronic device to support their blended learning process, although some classes however use no electronic devices and only written notes. Learners have freedom to select the device they want to use and the technology (ICT) staff offer support for any operating system to help the student implement their devices successfully. School A had been using devices as part of their teaching for roughly three years by the time the research was conducted. Candidate A has in fact been making use of a mobile device before the school introduced technology into their teaching program.

4.4.2 Interview responses

The first responses from Candidate A are summarised in table 4-1 below.

Table 4-1: Candidate A's interview responses Q1 – 7 (source: The Researcher)

Question 1	How long have you been using apps as part of your science lessons?	Three years.
Question 2	Have using apps enhanced your lessons in any way? If so, how?	Students can deliver products (e.g. movies) not only complete questions.
Question 3	Do you find that your learners experience your lessons different due to the use of apps? Explain.	Yes. They enjoy having all the different things to comeplete using their ipads.
Question 4	Do you use a tablet or ipad? And why the specific device?	Ipad. I had an Ipad before the school moved to devices. The school initially decided to go the Ipad route, but are now switching to 'bring your own device' senario.
Question 5	Who decided which device should be used?	The school.
Question 6	Did you get trained on using the tablet or ipad?	No.
Question 7	Who trained you. What were you trained in? When was the last training that you have attended or received?	N/A

As seen above in table 4-1, Candidate A has been using a mobile device for three years. The first year of use was on an Android operating system followed by a move to the IOP system and the participant expressed a 'love' for the iPad (in Q4).

When asked (in Q2) if the use of apps have enhanced Candidate A's lessons in any way, the response was that apps have indeed had a positive influence seeing that learners were given the opportunity to produce a product as feedback, i.e. a video or movie, to present their understanding on the topic. Candidate A feels this system adds value as learners are no longer only presented with questions and asked to answer the questions.

Candidate A is also of opinion that the apps have enhanced the lessons further (in Q3) as scholars are asked to 'do things' in a practical manner. Learners are involved and not static during the learning process and Candidate A therefore felt this was an ideal situation while teaching with apps.

Candidate A's school made the decision about the operating system to use (from Q5). Firstly the school preferred Apple and are now more flexible regarding the operating systems used by learners and are now encouraging learners 'to bring your own device'.

Teachers at Candidate A's school didn't get formal training on how to use apps in lessons but staff shared practice and ideas with each other(from Q6).

Table 4-2: Candidate A's interview responses Q8 – 13 (source: The Researcher)

Question 8	How have your lesson planning changed due to the implementation of apps in your lesson?	Lesson planing are time more consuming than it use to be for a traditional lesson.
Question 9	Which mobile educational applications (apps) do you use?	Notetaker (to mark assessments); Pages and numbers; Imovie; Inote; Key note (for powerpoint); Drop box; Edmodo (on the device and computer); Educreations (to record a lesson); Showme (where the learners add comments to explain their reasoning); Socrative; Exploriment (experiments or demonstrations); Race pigeon (a game to explain consept like energy); Coasterfriendzy (create your own roller coaster); You tube and NASA rocket building (curbol space program).
Question 10	How often do you use the above mentioned app/s? With your ipad class, do you use the Ipad in every single lesson?	The Ipad class get an Ibook to use and the paper class gets a hardbound book designed by our department.
Question 11	Why do you use the specific apps?	Notetaker to copy notes from lessons and Ibooks to access the book electronically.
Question 12	How do you use the app/s to support your lessons?	Notes and electronic documents, no hard copy are printed for these classes.
Question 13	Is there any app/s that you have decided not to use? And why?	N/A

In Q8 Candidate A comments on the time spent on lesson preparation in order to find the correct application of the app to support the lesson. In the past, learners were given work to complete and hand back. Adversly now, Candidate A finds that increased time is spent on looking for programmes that could add value to the lesson, and that process takes time.

It is apparent that Candidate A has built up a seemingly good knowledge of apps and programmes to support the teaching and therefore finds it easy to implement (from Q9). The participant has previously made use of various apps such as, like Note-taker; Pages and Numbers; i-Movie; i-Note; Keynote; Dropbox; Educreations; Edmodo; Showme and Socrative (from Q9). Most of these apps enable learners to add notes or produce a certain product, as mentioned earlier by the participant in Q2. When questioned regarding how Candidate A manages the classes that make use of apps but use books in addition, the participant explained that the school only uses standardised assessments and that each class will have their own non-standardised assessments based on the device or resources being implemented. Candidate A went on to explain the apps used by herself in the digital classroom: Coasterfriendzy; YouTube; Race-pigeon; Exploriment; Curbol Space Programme and Simple Rockets (from the discussion after Q9). Candidate A made a valid point during this discussion; that educators need to know what they want to teach and know the objectives they want to reach before setting off on trying to find the correct apps that will aid the learning process.

Candidate A converted some of the school's resources to an iBook (from Q10) for learners to download and use on their individual devices. These books are used daily by a class of which the learners all make use of iPads and learners can add notes and corrections in their iBook. Candidate A specifically states that this is not a 'pdf' type book, but an iBook. These apps support the flow of the lesson as learners can mail their work to the teacher and she responds digitally again to their work (from Q11). Candidate A is of the opinion that their learners have access to all their resources on an interminable basis and nothing can get lost or forgotten at home (from Q10).

Table 4-3: Candidate A's interview responses Q14 – 21 (source: The Researcher)

Question 14	Have you come across an app/s where the subject knowledge is incorrect?	Often.
Question 15	Who decides which apps are used in the lessons?	Myself.
Question 16	How is it decided which app/s to use?	Must match the task at hand.
Question 17	What should be considered when designing educational apps for science?	Active app, where learners do something and they get feedback.
Question 18	Have you experiences any problems with using app/s in lessons? If so, is there someone who can assist you?	No. If the learners experience problems the computer technicians can assist them.
Question 19	Are you aware of inquiry-based teaching as a teaching style?	Yes. I use this method extensively.
Question 20	If so, do you use your knowledge of inquiry-based teaching when using apps?	Yes, most of the time apps are used to support an inquiry-based activity.
Question 21	Would you encourage other educators to also use apps as resources and why?	Yes. It is a good way to encourage pupils to be active when learning, to search for answers.

When asked about the content of apps used in Science, Candidate A stated that she has come across many errors in the app (from Q14), but are vigilant enough to notice the errors and also be in a position to decide on what apps to use (from Q16). The participant hasn't come across any other problems while using apps in lessons (form Q 18) but mentions that their school has excellent IT support available for staff and learners to use.

During the second part of the interview, Candidate A was asked about her knowledge of inquiry-based teaching and the application thereof when selecting apps for science. Candidate A feels that she makes use of inquiry-based teaching in an extensive manner (from Q19) and feels that teaching with apps are mostly supporting the teaching style, where learners solve problems with the help of apps (from Q20).

Candidate A was asked to comment on the use of apps and the recommendation for other educators to use apps as well (in Q21). The participant argues that it is a good way to encourage pupils to be 'active' when learning and it the use of apps creates an easy way to look for the correct answers to a given problem. Candidate A suggests that using apps in teaching might be no different from other resources but goes on to add that the usefulness depends on the teacher's approach (from Q22).

Table 4-4: Candidate A's interview responses Q22 – 23 (source: The Researcher)

Question 22	How is using apps in teaching different than using other resoruces?	Not different, just another resource. The usefulness depends on the teachers approach.
Question 23	What don't you like about using tablet or ipads as resources? What do you wish you could change?	Not much - the teachers attitude determines the power of the resource.

During the last question (in Q23) Candidate A was asked to comment on something she would change about the use of apps in lessons. She could only think of one comment being that all pupils should have access to iPads. Again she mentions that the usefulness and power of the resource are determined by the teacher's attitude (from Q23).

4.4.3 Observation responses

Before conducting the research, the researcher expected to use an observation schedule to simply 'tick off' factors and apps as they were used by the educators. However, after the first case study, the researcher realised that the observation schedule was limiting the research in terms of only looking at certain factors and not observing the holistic case. Each observation was then observed using the factors proposed (*cf.* Section 3.7.2).

Lessons observed with Candidate A were focusing on electricity (Physics). All learners had access to their own devices (all learners had iPads) and access to the teachers' online textbook. The classrooms have enough power points for learners to charge their individual devices and all learners and staff have access to the schools' Wi-Fi service. The classroom is arranged in a group format and learners are encouraged to work together whenever possible.

Learners played with circuit boards in the first lesson therefore no devices were required and the teacher instructed learners to switch off their devices during this part of the lesson. Learners had no formal instruction from the teacher but the teacher modelled one question on the board: 'how do the current reading change due to various factors'? Learners were then left to explore their own ideas and 'design' their own practicals. In groups, learners constructed various different circuit diagrams and measure different variables.

Learners then used their textbooks to study the concept of currents. Learners could then play and 'explore' models to represent current moving.

The second lesson had a practical worksheet posed in the online textbook and learners were left in groups to complete the practical using electrical equipment. They added notes on the same page as the practical problem in their online textbook using an application. The teacher showed a Phet-video and learners discussed the phenomenon.

During lesson three in this observation learners completed an online circuit board test online (based on practical scenarios).

4.4.4 Questionnaire responses

The responses from Candidate A's questionnaire are summarised in table 4-5 below.

Table 4-5: Candidate A's questionnaire responses Q1 (source: The Researcher)

1. How important do you consider the following aspects when downloading an app?	Easy to use	Very important
	Cost	Considered
	Someone told me about the app	Considered
	Funky	Not important
	New or desirable features	Not important
	Scientifically correct	Most important
	Cirruculum related	Most important

As seen above in table 4-5 Candidate A pointed out that she considered the following factors when downloading an app (from Q1): 1.) curriculum related and scientifically correct; 2.) easy to use; 3.) cost, someone's recommendation; and lastly 4.) funky and desirable features.

Candidate A sees herself as a pro in terms of her skills on an electronic device (from Q2).

Table 4-6: Candidate A's questionnaire responses Q3 (source: The Researcher)

3. When using apps for a learning task, how important are the following in getting the job done?	My expectations	Considered
	The time it takes	Very important
	My skill level	Don't care
	Learners enjoyment	Very important
	My enjoyment	Don't care
	My mood	Don't care
	My motivation	Don't care
	The learners results	Considered
	Previous success	Considered

When asked in question three, as seen above in table 4-6, how important various factors are for Candidate A to get the job done while using apps, she never selected one of the factors as 'most important'. The two factors selected as highest on the list are the time it takes and the learners' enjoyment. Factors that were only considered by Candidate A are her own expectations; the learners' results and the previous success with the specific app. Candidate A suggests that these factors play no role in getting the task done: her skills level; her enjoyment; her mood and personal motivation.

Question four asked about the use of apps in lessons. Candidate A pointed out that the main reason she uses apps in lessons is to support her learners' understanding. Other factors she agrees with are the learners' response to apps and their relevance to the curriculum. Candidate A strongly disagrees with using apps for the following reasons: convenience; control of the technology; familiarity and a fashion statement.

Candidate A almost always uses apps to demonstrate concepts. Sometimes they are used to draw learners' attention or introduce a new concept. She also feels that lessons are kept interesting with the support of apps (from Q5).

'How important are the following factors for an app?' are asked in question 6. Candidate A selected the following as 'most important': relevant information; information is available to learners; information should encourage learners to think for themselves; information should pose other questions for learners, information should be current and up to date; and lastly the technical performance of apps. One of the 'very important' factors described is that the app must meet the requirements of all learners in the class is. Candidate A selected the following factors to be 'considered': information should be given in small sections; information should be available to download; information should be cheap and information should be relevant in a South African context. Candidate A was not concerned about 'age appropriateness should be indicated; developed by educational specialists and colourful information'.

In question seven the links between educational apps and entertainment apps are explored. Candidate A feels an educational app should lead to the production of a product, she feels apps are 'add-ons' to make learning relevant. Candidate A feels any app can be adapted to use in the classroom (from Q7.4).

Candidate A would recommend other educators to use apps when teaching science (from Q8) as she feels apps make learning more fun and relevant (form Q9).

When asked to select factors how apps support science education, Candidate A agreed with all the factors but selected her own motivation as most important (from Q10). Students' interest in science, students' understanding of concepts and students' skills in grasping complex concepts better are all equally selected as 'agree'.

Candidate A argues in question 11 that a teacher needs a sound understanding of an app to get value from it and this takes time to achieve.

4.5 RESPONSES – CASE STUDY B

4.5.1 Background

Case study B is an urban private school, employing the curriculum proposed by the Department of Education. Teachers are qualified and most have numerous years of teaching experience. The school is well-resourced and staff are well supported. One staff member focuses on the development of ICT policies, the school intranet and app selection by teachers. All learners at school B must buy their own devices to support their learning, some classes are still using hard copy books, but they aim for all learners to move to a device gradually over a certain period of time. School B has been making use of mobile devices for a duration of two years when the research was conducted.

Candidate B started using an Android device and then moved to iPad when the school considered using iTV.

4.5.2 Interview responses

The first responses form candidate B's interview are presented below in table 4-7.

Table 4-7: Candidate B's interview responses Q1 – 6 (source: The Researcher)

Question 1	How long have you been using apps as part of your science lessons?	Two years
Question 2	Have using apps enhanced your lessons in any way? If so, how?	Makes the abstract topics more concrete, makes the invisible visible for the learners. Apps are quicker and more accurate than an experiment.
Question 3	Do you find that your learners experience your lessons different due to the use of apps? Explain.	Yes. I use to do very little experiments and can now demonstrate ideas with videos.
Question 4	Do you use a tablet or ipad? And why the specific device?	Ipad. We used Android tablets at first, but sonsidered using I-TV. We also found that IStore has more educational apps.
Question 5	Who decided which device should be used?	Our IT specialist
Question 6	Did you get trained on using the tablet or ipad?	Yes. At school and the basics from Apple.

Candidate B has been using apps for two years (from Q1) and finds that apps enhance lessons by making abstract topics more concrete (from Q2). She explains that apps changed her lessons by allowing her to demonstrate ideas more quickly and more accurately compared to only doing a practical exercise (from Q3).

In question four Candidate B explains why their school moved from an Android operating system to an IOS system. The school considered using iTV and found more educational apps on IStore than Androids Play store. It seems from the answers that the IT specialist makes these decisions (from Q5) on his/her own. After switching from Android to iPads (iOS), the school offered training to staff as well as sending staff to Apple product training (from Q6).

Table 4-8: Candidate B's interview responses Q7 – 13 (source: The Researcher)

Question 7	Who trained you. What were you trained in? When was the last training that you have attended or received?	Apple trained us on basic settings and apps, like Ibooks and Imovie. The IT specialist did most of the training.
Question 8	How have your lesson planning changed due to the implementation of apps in your lesson?	I use a new app with each new topic
Question 9	Which mobile educational applications (apps) do you use?	Newtons craddle, Periodic table apps, Khan website, mathandscience.co.za, Colcampus, Phet and Everything science
Question 10	How often do you use the above mentioned app/s? With your ipad class, do you use the Ipad in every single lesson?	Learners use these apps as revision at home. I use apps to start a topic.
Question 11	Why do you use the specific apps?	Relevant information for each topic.
Question 12	How do you use the app/s to support your lessons?	We use Mindset reader.net for notes and books and dowload pdf documents for learners.
Question 13	Is there any app/s that you have decided not to use? And why?	Yes, some are too basic.

The IT specialist trained staff on the devices, the basic settings and apps like iBooks, iMovie, Colcampus (intranet) and Communicator (from Q7 as seen above in table 4-8). Candidate B felt that her lesson planning changed due to the addition of apps because she selects a new app for each new theme (from Q8). She explains in question 9 that she used various chemistry apps to show the periodic table and their properties. Other examples of apps (or websites) used are Newton's Cradle; Khan Academy; mathandscience.co.za; Colcampus; Everything Science and Phet.

In question ten Candidate B explained that apps are mostly used as an extra resource for the classes using devices. Learners can then explore ideas using simulations on various topics.

During lessons, apps are used to demonstrate experiments the educator are usually scared to do practically, but she continues that she would like to find an app showing the reactivity of elements.

When asked why you use the specific apps, Candidate B elaborated that she selects apps (form Q15) according to their relevance to the topics covered (from Q11). She also selects the apps herself and would not decline an app due to a cost involved if it is the last resort and no free alternative are available.

Candidate B says that they use books as interactive resources with links and videos included in the app; however, they sometimes struggle to access information (from Q12). If they encounter this problem, pdf copies are supplied to learners to use. Some apps are too basic or not relevant to the curriculum are provided as the only reasons why Candidate B has discontinued the use of a specific app (form Q13).

Table 4-9: Candidate B's interview responses Q14 – 21 (source: The Researcher)

Question 14	Have you come across an app/s where the subject knowledge is incorrect?	Yes, some parts of a website are sometimes not accurate.
Question 15	Who decides which apps are used in the lessons?	Myself.
Question 16	How is it decided which app/s to use?	Match the topic at hand.
Question 17	What should be considered when designing educational apps for science?	Relevant, interactive, experiments, interesting and colourful. Experiment interactive apps and show relevant theory. Must be grade specific.
Question 18	Have you experiences any problems with using app/s in lessons? If so, is there someone who can assist you?	Our IT specialist
Question 19	Are you aware of inquiry-based teaching as a teaching style?	Yes, like OBE or flipped classroom.
Question 20	If so, do you use your knowledge of inquiry-based teaching when using apps?	Sometimes we give the lessons as homework and discuss the finding in class.
Question 21	Would you encourage other educators to also use apps as resources and why?	Technology as a whole, it makes the subject more alive.

As seen above in table 4-9, Candidate B explains in question 14 that she hasn't come across apps that have incorrect information displayed but mainly found apps too basic or aimed at lower grades.

Candidate B selects apps herself (from Q15) by running a general search for applicable apps and attempts to match them to various topics (from Q16). In question 17 Candidate B explains that when designing educational applications they should be relevant, interactive and demonstrate experiments. Candidate B goes on to add that apps are more appealing to learners if they are colourful and interesting. Apps showing demonstrations should be designed to manipulate variables as well as link the relevant theory to the experiment.

During the second part of the interview Candidate B was asked to comment on inquiry-based teaching. She said they use inquiry-based teaching in science lessons by using techniques like flipped classroom (from Q19). Khan academy videos are used to support flipped classroom (from Q20).

Candidate B explains in question 21 that she would recommend any educator to use technology as this makes the subject come alive and be interactive (from Q22).

Lastly Candidate B sometimes struggled with unreliable internet and wished that South Africa was better connected (Q23).

4.5.3 Observation responses

The researcher observed lessons conducted by Candidate B, which were focused on Physics. All learners had access to a device. Some learners shared devices, although they had their own devise. There were eight learners in the class.

Candidate B showed a video from Khan Academy, however a video from the website was showed so the app was not used in this instance. Candidate B then used her own device to mark calculations on the board. Candidate B could stand behind or next to learners and write on the board.

Candidate B then experienced some issues with the internet when she tried to open the next application. The planned apps or activities were then written on the board for learners to 'explore' when they were home and connected to the internet again. Candidate B apologised and also mentioned that you have to be flexible when using technology as part of your teaching due to so many variables – internet connection or load-shedding, etc.

Students then accessed their textbook offline in the pdf format to complete calculations.

The second lesson observed was a smaller class with only six learners. Again all learners had their own devices as well as textbooks.

Candidate B was concerned that the school's internet connection which was unavailable negatively affected the fact that she wanted learners to view a video on the internet.

The educator showed a power point explaining the relevant theory to learners. All learners had access to the power point on their devices as well, as the educator mailed the notes to learners at the beginning of the topic as a pdf document.

Candidate B set homework using apps and suggested learners view the relevant videos on Khan Academy's app or website to aid their understanding.

4.5.4 Questionnaire responses

The responses for question one from Candidate B's questionnaire are presented below in table 4-10.

Table 4-10: Candidate B's questionnaire responses Q1 (source: The Researcher)

1. How important do you consider the following aspects when downloading an app?	Easy to use	Very important
	Cost	Considered
	Someone told me about the app	Very important
	Funky	Considered
	New or desirable features	Very important
	Scientifically correct	Most important
	Cirruculum related	Most important

Candidate B indicated in question one that she considered the following factors as 'most important' when downloading an app: scientifically important and curriculum related. Someone else's recommendation and user experience were both seen as 'very important'. The cost, funky design and desirable features were all only 'considered' by Candidate B.

Candidate B indicated in question two that she considered herself 'almost a pro' on the use of electronic devices.

Table 4-11: Candidate B's questionnaire responses Q3 (source: The Researcher)

3. When using apps for a learning task, how important are the following in getting the job done?	My expectations	Very important
	The time it takes	Very important
	My skill level	Very important
	Learners enjoyment	Very important
	My enjoyment	Very important
	My mood	Don't care
	My motivation	Considered
	The learners results	Very important
	Previous success	Very important

During question three Candidates were asked about the factors that support educators getting the job done. Candidate B only selected her expectations; the time it takes; her skills level; learners' enjoyment; her own enjoyment; the learners' results and previous success as very important factors. She only considered her own personal motivation and didn't take her own mood into consideration when selecting apps.

Question four focused on the reason for using apps during lessons. Candidate B felt that her main reasons to use apps in lessons were that she felt in control of technology; technology supported the leaners understanding; learners' response and was curriculum related. Candidate B agreed that using technology was convenient and she employed technology because she felt familiar with computers, tablets and the internet. She disagreed that using technology was a fashion statement.

The researcher can deduce (from Q5) that 'to draw learners' attention; demonstrate new concepts and keep lessons interesting' are some of the reasons why apps are used in lessons. Candidate B also indicated that she sometimes used apps to introduce new concepts.

In question six Candidate B indicated that the following factors were considered very important for an app: information should be relevant; information should be given in small sections; information should be available to learners; colourful information; downloadable; cheap information; encourage learners to think for themselves; pose questions with learners and the relevant age should be indicated on the application. Candidate B indicated that current information; South African content; developed by an educational specialist; meet the requirements of all learners in the classroom and perform well technically is the most important.

Candidate B argued that apps designed for education differed from educational apps as they were linked to the curriculum and learners should learn something every time they used apps (from Q7). The participant elaborated that making use of apps made the content more interesting, although she argued that there were not many usable and relevant apps available. Candidate B would only want apps to be more curriculum specific (from Q7).

Candidate B would recommend that other educators make use of apps (Q8) because it would enables them to make the invisible visible to their learners, allowing them to demonstrate quick and accurate experiments (Q9).

When asked how apps supported science education Candidate B 'strongly agreed' that students grasped concepts better; grasped complex ideas better and the educator was more motivated to teach science (from Q10). Candidate B also 'agreed' that learners were more interested in science due to apps used in lessons.

4.6 RESPONSES – CASE STUDY C

4.6.1 Background

Case study C is a rural Model C school located in a South African township employing the curriculum proposed by the Department of Education. Teachers are qualified and many have numerous years of teaching experience. The school and schooling system offer very little support to educators in terms of professional development, resources and financial aid to support the school's development. Classes are full with the minimum equipment and very few academic resources.

4.6.2 Interview responses

The first responses form Candidate C's interview are presented below in table 4-12.

Table 4-12: Candidate C's interview responses Q1 – 7 (source: The Researcher)

Question 1	How long have you been using apps as part of your science lessons?	Two years
Question 2	Have using apps enhanced your lessons in any way? If so, how?	To do past papers, to make videos when learners are explaining work for revision purposes.
Question 3	Do you find that your learners experience your lessons different due to the use of apps? Explain.	Things are easier since the tablet and learners results have improved.
Question 4	Do you use a tablet or ipad? And why the specific device?	First we used Prestige tablets, now Samsung with Android
Question 5	Who decided which device should be used?	Sponsors (CSIR)
Question 6	Did you get trained on using the tablet or ipad?	Yes
Question 7	Who trained you. What were you trained in? When was the last training that you have attended or received?	Sponsors (CSIR), Last training in July, trained in applications and basic use like camera, video, finding past papers and printing from the device.

Candidate C indicated that she had been using apps for two years when the study was conducted.

Asked about how apps had enhanced her lessons in any way, Candidate C indicated that apps made it easy to access resources like past papers. It was also easy for Candidate C to record or make notes on events that occur in class, using video or camera applications. According to Candidate C lessons can also be recorded and watched later on.

Candidate C argued that her lessons have improved since she started making use of apps in science (from Q3). The learners' results increased by fifty percent from one year to the next and she said the only thing that changed was the introduction of applications to lessons. Candidate C mentioned that even if educators (including herself) were absent learners could continue to access and practise work. She went on to explain that learners viewed videos online at their own convenience and then came to class with numerous questions about concepts they didn't grasp.

Candidate C had been using the device she had been issued with (from Q4), she started with a Prestige tablet using the Android operating system and has since moved to a Samsung tablet. Candidate C had no input in the selection of the preferred device (from Q5).

Extensive training was offered to staff as part of the initiative to use apps in teaching. Candidate C explained in question six and seven that it was hands-on practical training that she found most useful.

Table 4-13: Candidate C's interview responses Q8 – 16 (source: The Researcher)

Question 8	How have your lesson planning changed due to the implementation of apps in your lesson?	Time consuming
Question 9	Which mobile educational applications (apps) do you use?	ES-files, Adobe reader for past papers, Siyavula textbooks
Question 10	How often do you use the above mentioned app/s? With your ipad class, do you use the Ipad in every single lesson?	Not every day, but maybe when I start a new topic and revision for learners.
Question 11	Why do you use the specific apps?	
Question 12	How do you use the app/s to support your lessons?	Learners can access work even if I am absent
Question 13	Is there any app/s that you have decided not to use? And why?	No
Question 14	Have you come across an app/s where the subject knowledge is incorrect?	No mistakes.
Question 15	Who decides which apps are used in the lessons?	Myself
Question 16	How is it decided which app/s to use?	According to my lesson.

When asked how her lesson preparation had changed due to the implementation of tablets, Candidate C explained that she used the tablet more than her hard copy textbooks because it was easier. She had access to summaries which were easier to teach from (from Q8 and Q9). Apps were not used in every single lesson, but definitely to start a new topic (from Q10), Candidate C went on to add in question 11 that it was easier for her to use apps rather than other resources.

Candidate C argued that the main support offered to learners were the summaries they had access to on the devices (from Q12). Various apps were accessed and used by herself and learners, for example Siyavula, ES-files or adobe pdf's (from Q13). She had not come across any errors on apps except a few substitution errors on a past paper (from Q14).

The selection of applications was done solely by Candidate C (from Q15) and each teacher had the freedom to select their own applications as they prepared their lessons. Candidate C explained that she aimed to select apps that would support her lessons (from Q16).

Table 4-14: Candidate C's interview responses Q17 – 21 (source: The Researcher)

Question 17	What should be considered when designing educational apps for science?	Free for me and fit in with the lesson.
Question 18	Have you experiences any problems with using app/s in lessons? If so, is there someone who can assist you?	Some apps don't want to open on the tablet or it takes long to load.
Question 19	Are you aware of inquiry-based teaching as a teaching style?	Yes, I excange notes with my friend at a neighbouring school.
Question 20	If so, do you use your knowledge of inquiry-based teaching when using apps?	No.
Question 21	Would you encourage other educators to also use apps as resources and why?	Yes, it is good. We are a school of technology so we should be working with technology.

'Cost' and 'relevance to the curriculum' were two main factors highlighted in question 17 for app designers to take into account.

Only two issues, in question 18, were pointed out by Candidate C since they started using apps in class, which can be listed as ‘the internet connection was sometimes slow’ and ‘lessons were interrupted due to device batteries that died’.

In questions 19 and 20 when asked about inquiry-based teaching, Candidate C replied that she knew of a few teaching strategies but preferred only one. She would ask a colleague from a neighbouring school to share lessons plans with her. In this manner she could ensure that her learners had access to all the required theory. The researcher realised that Candidate C was not formally aware of inquiry-based teaching; however, could still be employing it during her lessons. This was one factor that the researcher wished to investigate further during the classroom observations and questionnaire.

Candidate C felt that their school was labelled a “technology secondary school”; however, not every subject had access to technology. She felt they needed to live up to the name and use apps in every subject area (from Q21).

Various factors were highlighted by Candidate C when asked how apps are different than using any other resource in question 22. She felt tablets had made work easily accessible. According to the participant one can ‘click on the resource you want to view and it opens, there is no need to search for something’. Another positive point Candidate C mentioned is the ‘portability of your device’ and that learners benefit from this greatly.

The researcher asked a few other questions before continuing with question 23. School C has very few resources, yet when asked about practicals Candidate C explained that she preferred to do hands-on practicals rather than using apps to demonstrate the outcome. Candidate C would not change anything with regard to using apps to ease the transition from traditional teaching to using applications during lessons. She actually commented in question 23 that she found it really straightforward to use. When asked at the end of the interview to define an application, Candidate C used powerful words like ‘portable’; ‘encourages group learning’; ‘easier’; ‘access while you perform other tasks’ for instance commuting and the ability to carry more information with you.

4.6.3 Observation responses

During the first classroom observation at this school, the class was busy with a topic in Physics. Classes had to accommodate a larger audience (between 30 and 35 learners) compared to earlier cases observed in this study. Very basic equipment filled the classroom, a green chalk board could be found at the front of the classroom with wooden benches and chairs scattered around the classroom. Learners sat next to each other and some shared devices.

The teacher had set homework from a past examination paper. Learners had access to the papers on their devices and attempted the questions on their own time at home. They used the device to view the questions and wrote their solutions on paper.

Back in class the next day, the teacher checked homework and asked a few volunteers to present their solutions on the board. Three learners volunteered. The three learners all stood at the green board and wrote out the solution to a different question. Once the learners had completed their solutions on the board, the teacher asked another volunteer to talk the class through the steps. The volunteer then stood in the front of the class and explained the steps on the board. One learner had a question on one of the steps and the teacher 'stepped in' to explain that it was not necessary to show this step, if you understood the function. The volunteer continued to talk through the various steps to the solutions on the board.

The bell rang and the teacher wrote down three sums for homework from a past examination paper.

Lesson observation two, was different in terms of teaching and the employment of the device; however, the layout of class and the number of learners were more or less the same. Lesson two introduced a new topic.

Learners followed with the teacher as she read from a pdf document - mainly theory. Some learners shared devices with their friends. Some learners made additional notes in their workbook as the teacher read.

Candidate C then used a past paper on her device to access one of the sums. She directed learners to the same question. This question was done on the board as an example for learners. A second sum was then given to learners to attempt by themselves or in small groups.

The bell rang and Candidate C wrote down three calculations that could be accessed on the device from a past examination paper as homework to be completed by learners.

4.6.4 Questionnaire responses

The first responses from Candidate C's questionnaire are presented below in table 4-15.

Table 4-15: Candidate C's questionnaire responses Q1 (source: The Researcher)

1. How important do you consider the following aspects when downloading an app?	Easy to use	Very important
	Cost	Considered
	Someone told me about the app	Very important
	Funky	Considered
	New or desirable features	Considered
	Scientifically correct	Most important
	Cirruculum related	Most important

Candidate C indicated in the first question that she considered curriculum relevant and scientifically correct apps as the most important factors when downloading an app. The users' experience and a recommendation from someone else were high on the list and considered as 'very important' factors. The cost; funkiness and desirable features were only 'considered'.

Candidate C considered her skills on the device as 'almost a pro' (from Q2).

Table 4-16: Candidate C's questionnaire responses Q3 (source: The Researcher)

3. When using apps for a learning task, how important are the following in getting the job done?	My expectations	Very important
	The time it takes	Most important
	My skill level	Considered
	Learners enjoyment	Very important
	My enjoyment	Very important
	My mood	Very important
	My motivation	Very important
	The learners results	Considered
	Previous success	Considered

Question three asked how important various factors were when considering using apps for a learning task, the time it took was most important to Candidate C. Factors that were 'very important' included her own expectations; learners' enjoyment; her mood and her own personal motivation. The teachers' skills levels; learners' results and previous success were all 'considered'.

When asked in question four why Candidate C used apps in her lessons, she 'agreed' with all options, none were indicated as 'strongly agree'. These factors included convenience; in control of technology; familiar; fashion statement; supportive of students' understanding; learners' response and curriculum related.

Apps were used by Candidate C 'mostly' to demonstrate concepts according to question five. She 'sometimes' used apps to draw learners' attention; introduce new concepts and keep lessons interesting.

Information that is seen as 'most important' for an app is current information and meeting the requirements of all learners in the classroom. 'Very important' is relevant information; information should be available to learners; should encourage learners to think for themselves; South African information; developed by educational specialists and the technical performance of apps. Factors to only 'consider' are that information should be provided in small sections; information should be downloadable and should be cheap. Colourful and age indication are two factors considered as 'not important' by Candidate C (from Q6).

In question seven Candidate C indicated that 'time saved' was a main reason how educational apps differed from entertainment apps. Apps 'help me understand some concepts' (also from Q9) and there is nothing she would change about her experience with apps. She would 'most definitely' recommend other educators to also use apps in teaching (from Q8).

Apps support science teaching due to the fact that both educators and students are more interested in the subject (from Q10). Candidate C 'agreed' that apps aid students' understanding and assist them to grasp concepts better.

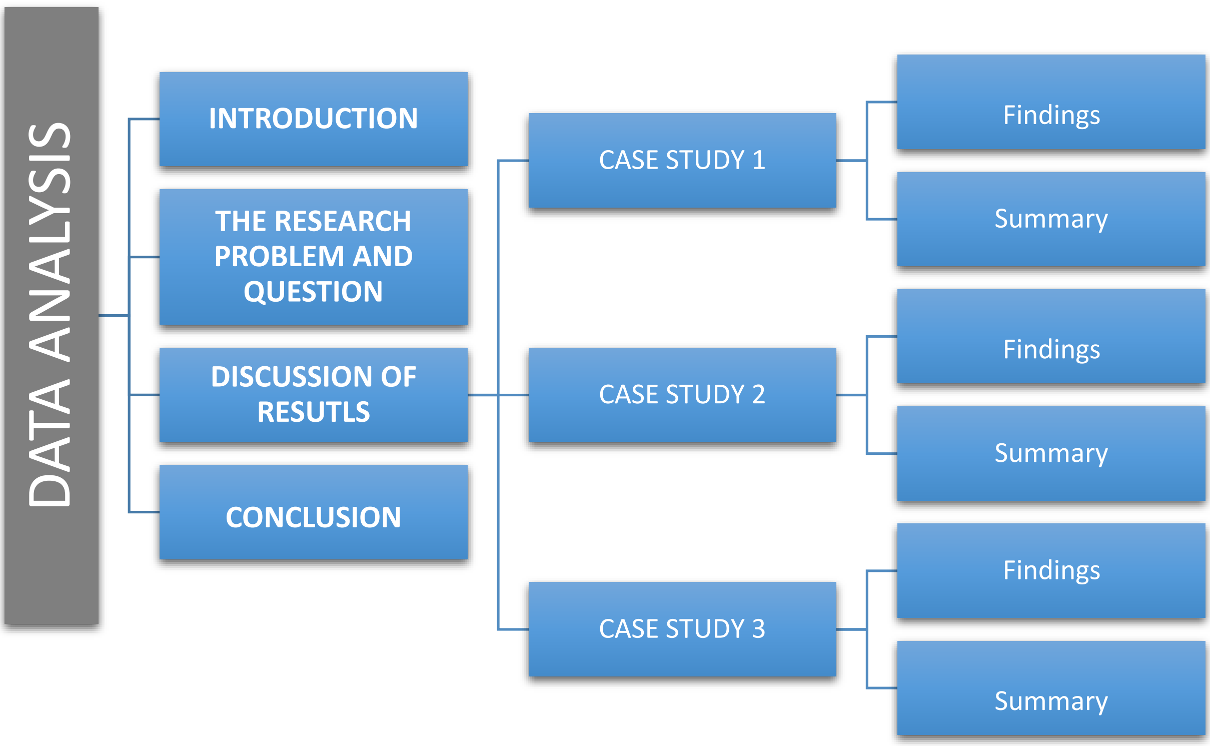
4.7 CONCLUSION

Chapter 4 presented each case study as an individual case, as stated by Creswell (2014) the first step is a within-case analysis. All three data collection methods were presented and discussed; including the semi-structured interview responses, classroom observations and questionnaire responses.

In chapter 5 the rest of Creswell's (1994) suggestions for case study analysis are used to compare the responses from all three case studies to each other (cross-case analysis) in order to come to a conclusion taking into account all the data collected (holistic-case analysis).

5. CHAPTER 5: DATA ANALYSIS

Map of Chapter 5: DATA ANALYSIS



5.1 INTRODUCTION

Chapter 4 presented the data collected from the three case studies. All the data gathered for each case were discussed individually. The data collected from the open-ended interviews, classroom observations and questionnaires were individually presented.

In chapter 5 a comparison between the three cases are drawn in the aim to present the findings that would ultimately be used to develop a set of guidelines to select apps that are appropriate for Physical Sciences in the FET phase.

5.2 THE RESEARCH PROBLEM AND QUESTION

The study thus far has provided a preliminary answer from literature reviews towards answering the research questions. The three case studies aim to answer the research sub-questions, but for the main question we compare our findings with the literature review (*cf.* Table 6-1).

For each case study, the teachers' interviews were analysed, written descriptions of their lessons and the results provided from the questionnaires. Each school was compared individually before a comparison among the three cases were made and further compared the findings with the literature.

5.3 DISCUSSION OF RESULTS

Mentioned in the methodology chapter earlier on the interpretation process should also be supported by the seven principles of interaction between the researcher and subjects as stated by Klein and Myers (1999). The principles proposed by Klein and Myers (1999) that were used to evaluate the interpretative case study are presented below in table 5-1.

Table 5-1: Principles for conducting and analysing interpretive research *(source: adapted from Klein & Myers, 1999)*

7 Principles for conducting and evaluating interpretative studies:	**How the principle was utilised during the data collection and analysis of this study:**
1. The principle of the hermeneutic circle: This principle is the driving force of the process, as it will guide the application of the other principles. This principle seeks to find the sense of individual elements and how they fit together as a whole. This refers to the processing of data collection, where the interpretative researcher is seeking data that is ever changing and therefore a cyclical process that supports the data-gathering process, as directed by the hermeneutic circle.	During data analysis this principle was applied in part and whole using Creswell's (1994) case-study analysis template. Looking at each case individually and then making a cross-case analysis. The ultimate step was a holistic case analysis, which is used to draw the conclusion.
2. The principle of contextualisation: The researcher must embrace the social and historical differences to continually seek meaning in context of the data presented. Another vital point is to perform the research in the subject's context so the researcher can observe the data and how it is affected by all external components.	The researcher evaluated how apps were used by examining each case. Experiencing and observing each case's environment, background and social differences.
3. The principle of interaction between the researchers and the subjects: This principle requires the researcher to experience the social context of the subject. Due to the nature of the study, where data are gathered from people with the help of social interaction, careful thought has to be given on how the data were socially constructed due to the interaction of the researcher and the participants.	This was observed during the visits to the three educators. The researcher interacted with the educators and observed during lessons how the educators use apps. The researcher experienced first-hand how each case operated and how social and historical differences influenced the case.
4. The principle of abstraction and generalisation: Theory plays a fundamental role in the interpretive research and is used to direct the thoughts of the researcher in a certain way, especially by using understanding in one phase to anticipate the prediction of the next phase. The requirement to apply a theory or concept that describes the nature of human understanding and social action is of crucial importance in this principle.	The same study was applied to three cases from different backgrounds, to ultimately aid the researcher with generalisation.

5. The principle of dialogical reasoning: This step requires that researchers alter their presumption that they used as direction for the research design. The possible recognition of contradictions between the theoretical preconceptions guiding the design and the actual data collected.	The data analysis process and data analysis were a comparison between the literature study and data collection analysis.
6. The principle of multiple interpretations: The possibility that participants could account for the same detail in various manners. This principle is not always evident during research, but must be accounted for.	The literature study and the data collection process pointed out possible guidelines that could be used to select apps (*cf.* Table 2-2).
7. The principle of suspicion: The least descriptive principle in literature is the possibility that participants might be biased in some way, however this points out another issue of how the researcher could possibly prove this and it is argued that some researchers rather do not follow this principle in their work.	Multiple sources of data collection were employed and multiple measures for data collection were used (semi-structured interviews, observations and questionnaires).

5.3.1 Data-analysis process

The findings from each case are presented below; first all the data gathered are presented individually and then a comparison between the three cases is drawn (cf. Section 5.4).

The interview questions presented the researcher with the most important factors proposed by each case. Educators had the opportunity to elaborate on their answers and present confirmation of how they employ apps in their lessons. The questionnaire was completed last and was used to verify the findings and triangulate between the data found in the interview and classroom observation.

Questions used in the questionnaire were designed so that when respondents were presented with options they had four choices to pick from. During the data analysis process the researcher decided instead of presenting the data just as an explanation a scaled response would make it easier to differentiate among the various factors investigated. The responses were classified according to the four options. The strongest option was allocated a 100% rating, the second strongest 75% and a 50% and 25% thereafter (*cf.* Table 5-2; Table 5-3 and Table 5-4). This allowed the findings to be ranked in order of importance and ultimately allowed the researcher to rank the factors in order of status to each case (*cf*. Figure 5-1; Figure 5-2 and Figure 5-4).

After each case the data were presented as a summarised graph indicating the percentage value to each factor investigated (*cf*. Figure 5-4).

5.3.2 Case Study 1 – Elite private school

Candidate A had a great deal of experience in using devices, taking into account that most schools have only started to use technology to support education. Candidate A also has her own device and knew how the software worked before the school suggested the use of devices. Candidate A is well-qualified and has wide teaching experience.

Findings

Candidate A placed interactivity, curriculum fit and the students' response in the top three factors for selecting an application to use in their lessons. The rank of factors for Candidate A can be seen below in table 5-2 below.

Table 5-2: Factors proposed by Candidate A (source: The Researcher)

Reasons for selection	Relevant question : Questionnaire	Total %
Interactive	5.3 = 100	100%
Curriculum fit	1.7 = 100; 3.8 = 50; 4.5 = 100; 4.7 = 75; 6.1 = 100; 6.8 = 100; 6.9 = 100	89.29%
Scientific content	1.6 = 100; 3.8 = 50; 4.5 = 100; 4.7 = 75; 5.2 = 50; 6.1 = 100; 6.8 = 100; 6.10 = 50	78%
Students' response	4.6 = 75; 3.4 = 0; 3.8 = 50; 5.1 = 50; 5.4 = 75; 6.3 = 100; 6.6 = 75; 6.7 = 100; 6.11 = 25; 10.1 = 75; 10.2 = 75; 10.3 = 75	70.45%
Customisation	6.1 = 100; 6.2 = 50; 6.9 = 100; 6.11 = 25; 6.12 = 75	70%
Personal perception / experience	3.1 = 50; 3.3 = 0; 3.5 = 75; 3.6 = 0; 3.7 = 0; 3.9 = 50; 4.3 = 0; 10.4 = 100	68,75%
Cost	1.2 = 50; 6.5 = 50	50%
User friendliness	1.1 = 75; 3.2 = 75; 3.3 = 0; 4.1 = 0; 4.2 = 0; 6.2 = 50; 6.11 = 25; 6.13 = 25	50%
External source	1.3 = 50	50%
Appeal	1.4 = 0; 1.5 = 0; 4.4 = 0; 5.1 = 50; 5.4 = 75; 6.4 = 25	50%

As seen in table 5-2 above Candidate A feels that the three most important factors for selecting apps should be: 1.) interactivity (100%); 2.) fit with curriculum topics (89.29%) and 3.) scientifically correct (78%).

These factors were also supported during the interview with Candidate A. Each factor is presented below and then finally summarised.

Factor 1: Interactive

In Q2 Candidate A was asked 'have using aps enhanced your lessons in any way?' Candidate A answered: Students can *deliver products* for example a movie and not only sit and complete questions.

Later during the interview when asked again 'about what should be considered when designing educational apps for science' in Q17. Candidate A answered: *active apps*, where learners do something and they *get feedback*.

In Q21 Candidate A answered that apps encourage learners to be *active while learning* and they search for answers. She said that for this reason she would encourage other educators to also use apps as resources.

'An app should lead to the *production of a product*' is one of the factors Candidate A mentions in Q7.1 when asked about the difference between educational apps and apps for entertainment.

Factor 2: Curriculum fit

Q16 asked 'how is it decided which app to use?' Candidate A said the app must *match the task at hand*.

Candidate A later stated in Q7.4 that all though it would be an advantage that apps *fit the curriculum*, a good educator can with a little effort and time match any application to the classroom situation as long as the content is correct.

Factor 3: Scientifically correct

Candidate A said that she had often deleted apps or discontinued their use because she found the *subject knowledge to be incorrect* in Q14.

During the questionnaire (Q1.7) Candidate A indicated that when downloading an app she considers how *related the app is to the curriculum* as one of the 'most important' factors.

Candidate A mentioned that any app could be altered to match a task in the classroom as long as the *content was correct* (Q7.4).

Customisation (70%); students' response (70.45%) and personal perception (68.75%) also scored high during Candidate A's interview and questionnaire.

Factor 4: Customisation

In Q17 Candidate A mentioned that apps should be active and learners must be able to get feedback, during the questionnaire she gave high scores for the following factors: 1.) Relevant apps; 2.) Given in small sections; 3.) Current and up to date; 4.) Appropriate for all learners in the class.

This was summarised as factors that *should be customised* and altered for the specific task at hand for individual classes.

<u>Factor 5: Students' responses</u>

In Q3 Candidate A said learners experienced her lessons differently due to the use of apps, they *'enjoyed* having all the different *things to complete* using their iPads'.

'Active apps, *where learners do something* and get feedback' is what Candidate A consider as factors in Q17 that should be considered when someone is designing educational apps for science.

<u>Factor 6: Personal perception</u>

Candidate A as she experienced her learners were now *'participating* and delivering products'.

When asked in Q12 'How do you use apps to support your lessons?' Candidate A mentions that she doesn't print hard copies for her classes, they download information or documents and add notes electronically – this *saves time* and preparation.

In Q9 Candidate A was asked 'How do apps enable you to do something you were unable to do in the past?' Candidate A responded that apps made learning *fun and relevant.*

Asked about the same topic as in Q9, Candidate A answered that apps supported science by *motivating* students and *assisting students* to grasp concepts better. Candidate A also said that she felt more *motivated to teach science* with the help of technology.

Candidate A mentioned that a teacher needs to have a sound understanding of an app (Q11) and science content (Q7.4) to get any value from using apps and this takes time. Asked about her awareness of inquiry-based teaching as a teaching style in Q19, Candidate A responded that she 'use this method extensively'. Candidate A responded in Q20 that most apps are used to support an inquiry-based activity and that she used her knowledge of inquiry-based teaching when using apps.

Summary

Figure 5-1 below represents a concise graph (*cf*. Section 5.3.1). The reasons to select an application are presented below in alphabetical order for school A.

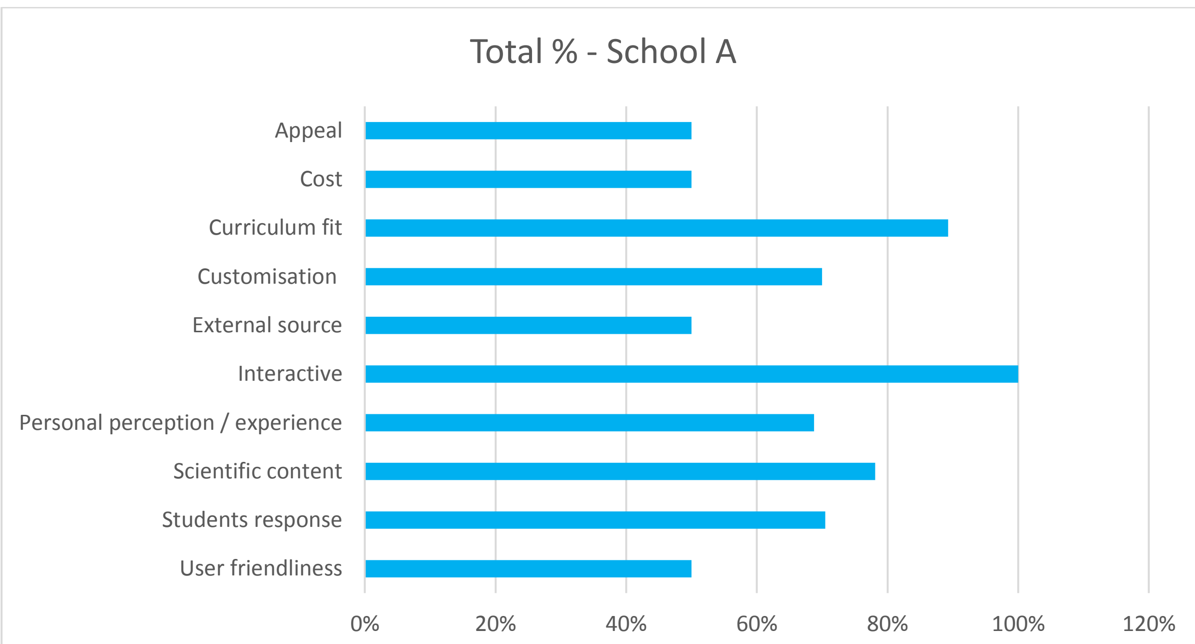


Figure 5-1: Total percentage for school A (source: The Researcher)

- Candidate A put the most emphasis on the following factors for selecting apps: 1.) interactive (100%); 2.) curriculum fit (89.29%); 3.) scientifically correct (78%); 4.) customisation (70%); 5.) students' response (70.45%); and 6.) personal perception (68.75%).

- Candidate A has a sound understanding of both selecting apps and inquiry-base teaching; however she consider herself a learner on devices (Q2).
- Candidate A feels that apps can support science education and are good tools to support inquiry-based activities.

5.3.3 Case Study 2 – Urban school

Candidate B had more than two years' experience in using a device as an educational resource. Candidate B had used a variety of devices from various service providers. Candidate B was well qualified and had experience in especially science remedial and revision workshops.

Findings

Candidate B placed curriculum fit, scientific content and customisation in the top three factors for selecting an application to use in her lessons. The ranking of factors for Candidate B can be seen below in table 5-3.

Table 5-3: Factors proposed by Candidate B (source: The Researcher)

Reasons for selection	Relevant question : Questionnaire	Total %
Curriculum fit	1.7 = 100; 3.8 = 75; 4.5 = 100; 4.7 = 100; 6.1 = 75; 6.8 = 75; 6.9 = 100; 6.10 = 100	91%
Scientific content	1.6 = 100; 3.8 = 75; 4.5 = 100; 4.7 = 100; 5.2 = 50; 6.1 = 75; 6.9 = 100; 6.11 = 100	88%
Customisation	6.1 = 75; 6.2 = 75; 6.9 = 100; 6.11 = 100; 6.12 = 100; 6.13 = 75	88%
Students' response	4.6 = 100; 3.4 = 75; 3.8 = 75; 5.1 = 75; 5.4 = 75; 6.6 = 75; 6.7 = 75; 6.8 = 75; 6.11 = 100; 10.1 = 75; 10.2 = 100; 10.3 = 100	83%
User friendliness	1.1 = 75; 3.2 = 75; 3.3 = 75; 4.1 = 75; 4.2 = 100; 6.2 = 75; 6.14 = 100	82%
External source	1.3 = 75	75%
Interactive	5.3 = 75	75%
Personal perception / experience	3.1 = 75; 3.3 = 75; 3.5 = 75; 3.6 = 25; 3.7 = 50; 3.9 = 75; 4.3 = 75; 6.5 = 75; 10.4 = 100	69%
Cost	1.2 = 50 ; 6.5 = 75; 6.6 = 75	67%
Appeal	1.4 = 50; 1.5 = 75; 4.4 = 50; 5.1 = 75; 5.4 = 75; 6.4 = 75	67%

As seen in table 5-3 above Candidate B feels that the three most important factors for selecting apps should be: 1.) fit in with curriculum topics (91%); 2.) scientific content (88%) and 3.) customisation (88%).

These factors were also supported during the interview with Candidate B.

<u>Factor 1: Curriculum fit</u>

In Q10 Candidate B states that she used apps to *start new topics* and that apps being *curriculum related* is one of the most important factors when considering apps as a resource.

One of the reasons Candidate B would not use a specific app if she found that some of the *subject knowledge is incorrect* (Q14).

Candidate B describes in Q16 that she decides which apps to use on the fact that it 'must *match the topic at hand'*.

When asked in Q17 'what should be considered when designing educational apps for science?' Candidate B mentions a few factors, but repeat the fact that apps must be '*relevant*' and show '*relevant theory'*.

<u>Factor 2: Scientific content</u>

In Q10 Candidate B refers to the fact that she used apps to *start topics* and that apps had to be *accurate* (Q14).

In Q17 Candidate B says that factors to consider when designing new apps had to be '*relevant, grade specific and correct'*.

<u>Factor 3: Customisation</u>

Candidate B mentions that she found her learners' experience her lessons different due to the use of apps. She went on and explain in Q3 that apps must *allow for data to be changed* (customised), to demonstrate ideas and illustrate experiments.

In Q17 Candidate B said that when designing apps one of the factors to consider was the ability to *show experiments* (customise) with all the variables.

Students' responses (83%); user friendliness (82%); external sources (75%) and interactive (75%) also scored high during Candidate B's interview and questionnaire.

<u>Factor 4: Students' responses</u>

Candidate B explained that students must have a *positive experience* when using apps in order for the apps to support the lessons (Q12).

In Q17 Candidate B explained that apps must be '*relevant* to students, they must find them interesting and respond to the content'.

When asked about the difference between apps and other resources in Q22, Candidate B said students find apps '*interactive and content comes alive'*.

<u>Factor 5: User-friendliness</u>

When asked in Q2 'have using apps enhanced your lesson in any way?' Candidate B answered that apps 'make the invisible visible, the abstract concrete and *apps are quicker and more accurate* than an experiment'.

Candidate B said in Q13 some apps are too basic and *not user-friendly for the age group* and that she would not use it, because one of the main factors for a positive user experience is that apps must match the topic at hand (Q16).

Candidate B feels that apps make the subject more *user-friendly and alive* (Q21) but finds that there are *few apps to select from* to use in science (Q23).

<u>Factor 6: Interactive</u>

When asked 'how has using apps enhanced your lesson in any way?' Candidate B answered that apps were accurate, *interactive* methods to *demonstrate* experiments and an easy way to make abstract topics more concrete (Q2).

Candidate B found that learners experienced her lessons differently due to apps (Q3) because she can now *demonstrate experiments*.

In Q17 Candidate B said *interactive apps* were one of the factors that should be considered when designing educational apps for science and that technology makes science more *interactive and alive* (Q21;Q22).

Candidate B mentioned that learners should learn something through using apps (Q7.1) but struggle to find useful and relevant apps (Q7.3). When asked about what she would change about apps used for education in Q7.4 she shouted ‘*HAVE MORE!*’

When asked about her awareness of inquiry-based teaching as a teaching style in Q19, Candidate B responded ‘like OBE or flipped classroom?’ In Q20 Candidate B explained that she sometimes gave the lessons as homework and discussed the findings in class.

Summary

Figure 5-2 below represents the reasons to select an application in alphabetical order for school B.

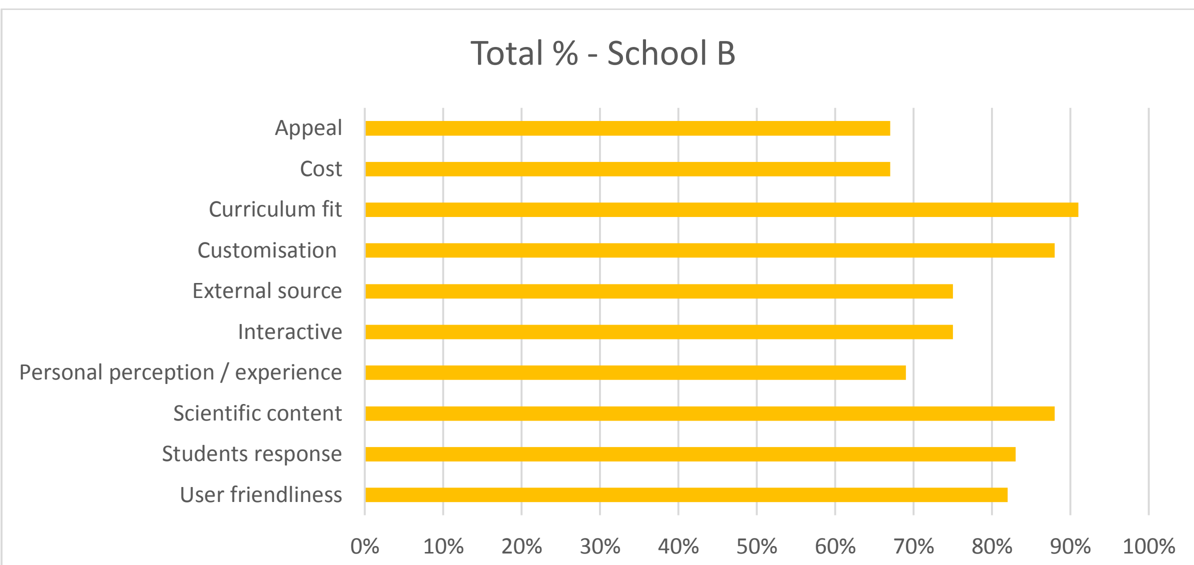


Figure 5-2: Total percentage for school B (source: The Researcher)

Using figure 5-2 above, we can conclude:

- Candidate B put the most emphasis on the following factors for selecting apps: 1.) curriculum fit (91%); 2.) scientific content (88%); 3.) customisation (88%); 4.) students' responses (83%); 5.) user friendliness (82%) and being interactive (75%).
- Candidate B has a thorough understanding of apps and the tasks it can fulfil.
- Candidate B feels that apps can support science education through demonstrating experiments.

5.3.4 Case Study 3 – Rural School

Candidate C had two years' experience in using devices as a resource. Candidate C has used a variety of traditional methods to assist her teaching.

Findings

Candidate C placed scientific content, external sources and interactive in the top three factors for selecting an application to use in lessons. The ranking of factors for Candidate C can be seen below in table 5-4 below.

Table 5-4: Factors proposed by Candidate C (source: The Researcher)

Reasons for selection	Relevant question : Questionnaire	Total %
Scientific content	1.6= 100; 3.8 = 50; 4.5 = 75; 4.7 = 75; 5.2 = 50; 6.1 = 75; 6.9 = 100; 6.11 = 75	75%
External source	1.3 = 75	75%
Interactive	5.3 = 75	75%
Curriculum fit	1.7 = 100; 3.8 = 50; 4.5 = 75; 4.7 = 75; 6.1 = 75; 6.8 = 25; 6.9 = 100; 6.10 = 75	72%
User friendliness	1.1 = 75; 3.2 = 100; 3.3 = 50; 4.1 = 75; 4.2 = 75; 6.2 = 50; 6.14 = 75	71%
Customisation	6.1 = 75; 6.2 = 50; 6.9 = 100; 6.11 = 75; 6.12 = 100; 6.13 = 25	71%
Personal perception / experience	3.1 = 75; 3.3 = 50; 3.5 = 75; 3.6 = 75; 3.7 = 75; 3.9 = 50; 4.3 = 75; 6.5 = 50; 10.4 = 100	69%
Students response	4.6 = 75; 3.4 = 75; 3.8 = 50; 5.1 = 50; 5.4 = 50; 6.6 = 50; 6.7 = 75; 6.8 = 25; 6.11 = 75; 10.1 = 100; 10.2 = 75; 10.3 = 75	65%
Cost	1.2 = 75; 6.5 = 50; 6.6 = 50	58%
Appeal	1.4 = 50; 1.5 = 50; 4.4 = 75; 5.1 = 50; 5.4 = 50; 6.4 = 25	50%

As seen in table 5-4 above Candidate C feels that the three most important factors for selecting apps should be: 1.) scientific content (75%); 2.) external source (75%) and 3.) interactive (75%).

These factors were also highlighted during the interview with Candidate C.

<u>Factor 1: Scientific content</u>

Even though most of Candidate C's results pointed to scientific content in the questionnaire, her interview showed less indication of scientific content; however Candidate C said that apps were *used to start a new topic* and later when learners wanted to do revision (Q10).

Candidate C mentioned in Q14 that she had never come across apps that had *errors with scientific content.*

<u>Factor 2: External source</u>

When asked about external sources affecting the selection process, Candidate C said that some apps *don't want to open and take long to load* (Q18).

Candidate C said that she selected most apps on the '*recommendation from someone'* outside school (Q1.3).

<u>Factor 3: Interactive</u>

When asked in Q2 'how have using apps enhanced your lessons in any way?' Candidate C explained that apps allowed students to *use videos* to understand content and later do revision.

Apps *should be interactive* and shared between educators says Candidate C to help them with their preparation (Q19).

Curriculum fit (72%); user friendliness (71%); and customisation (71%) also scored high during Candidate C's interview and questionnaire.

Factor 4: Curriculum fit

Candidate C said apps were used for revision and doing past papers (Q2). She went on to explain in Q2 that learners made recordings of the lessons and used this as *revision for their examinations* (Q10).

Apps are used by Candidate C to *start a new topic* and get learners interested in the work (Q10).

Apps are *selected according to lessons* and matched to the topic at hand (Q16).

Factor 5: User friendliness

In Q2 Candidate C explained that apps should *make learning easier* and encourage learners to do revision.

Candidate C explained in Q8 that apps should be *efficient* and save the user time.

Apps are selected by Candidate C (Q15) according to *user friendliness* and some apps are not used by Candidate C due to the fact that it takes too long to load or refuse or struggle to open (Q18).

Apps are used by Candidate C to *enhance the user experience* during lessons (Q22), to ensure lessons are interesting and draw the learners' attention.

Factor 6: Customisation

Candidate C explained that apps should *be relevant* (Q6.1) and should demonstrate *concepts in small sections* (Q6.2).

In Q6.12 Candidate C explained that apps should indicate for what *age* they were appropriate and the user should be *able to adjust the app* for differentiation or different ages.

Candidate C mentioned that using apps as educational resources was saving her time (Q7.1) and goes on to say in Q7.2 and Q9 that using apps helped her (the teacher) to understand concepts by explaining concepts clearly.

When asked what should be considered when designing educational apps, Candidate C said that apps needed to be free and fit in with the lesson (Q17).

When asked about her awareness of inquiry-based teaching as a teaching style in Q19, Candidate C responded 'yes, I exchange notes with my friend from a neighbouring school' and goes on to say in Q20 that she doesn't use enquiry-based teaching when using apps.

Summary

Figure 5-3 below represents the reasons to select an application in alphabetical order for school C.

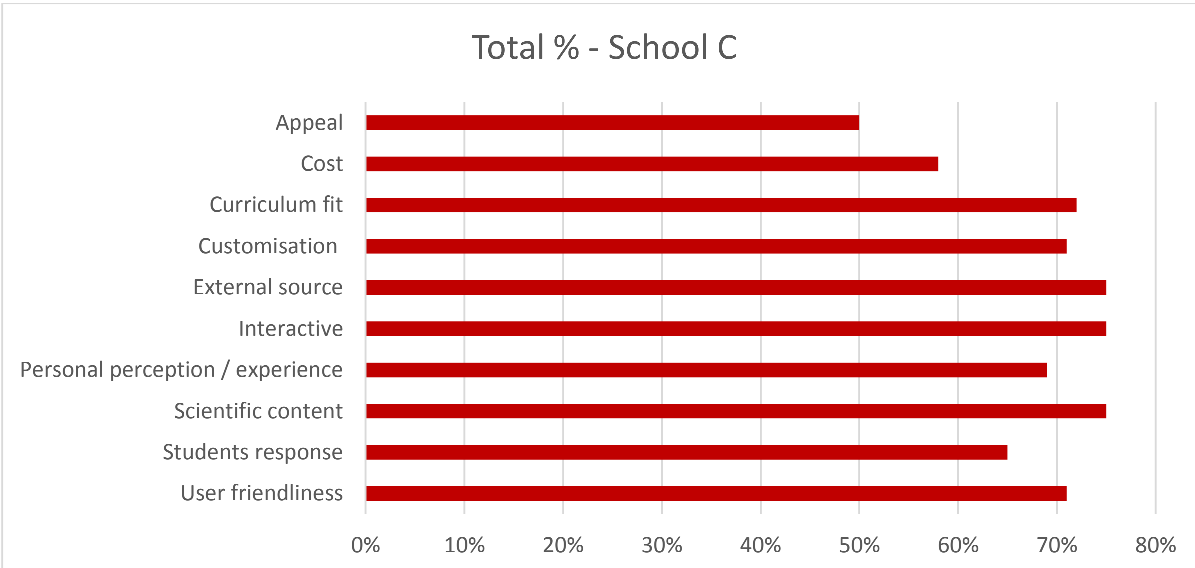


Figure 5-3: Total percentage for school C (source: The Researcher)

Using figure 5-3 as above we can conclude:

- Candidate C puts the most emphasis on the following factors for selecting apps: 1.) scientific content (75%); 2.) external source (75%); 3.) interactive (75%); 4.) Curriculum fit (72%); 5.) user friendliness (71%); and 6.) customisation (71%).
- Candidate C has had training in using apps and understands the tasks technology can fulfil.
- Candidate C feels that apps are making her task as a teacher easier, but are sometimes limiting her due to poor internet connections and apps that take long to load.

5.4 FINDINGS: COMPARISON BETWEEN CANDIDATES A, B AND C

5.4.1 Selection and use of apps - findings

The data found in the interviews were also supported by the questionnaires and therefore the researcher used the rankings from the questionnaire responses to graphically present the data from each case as explained earlier (*cf.* Section 5.3.1), to highlight the most important factors per case.

Comparing the results from schools A, B and C as below in figure 5-4, we can see four factors that were emphasised as equally important in all three schools.

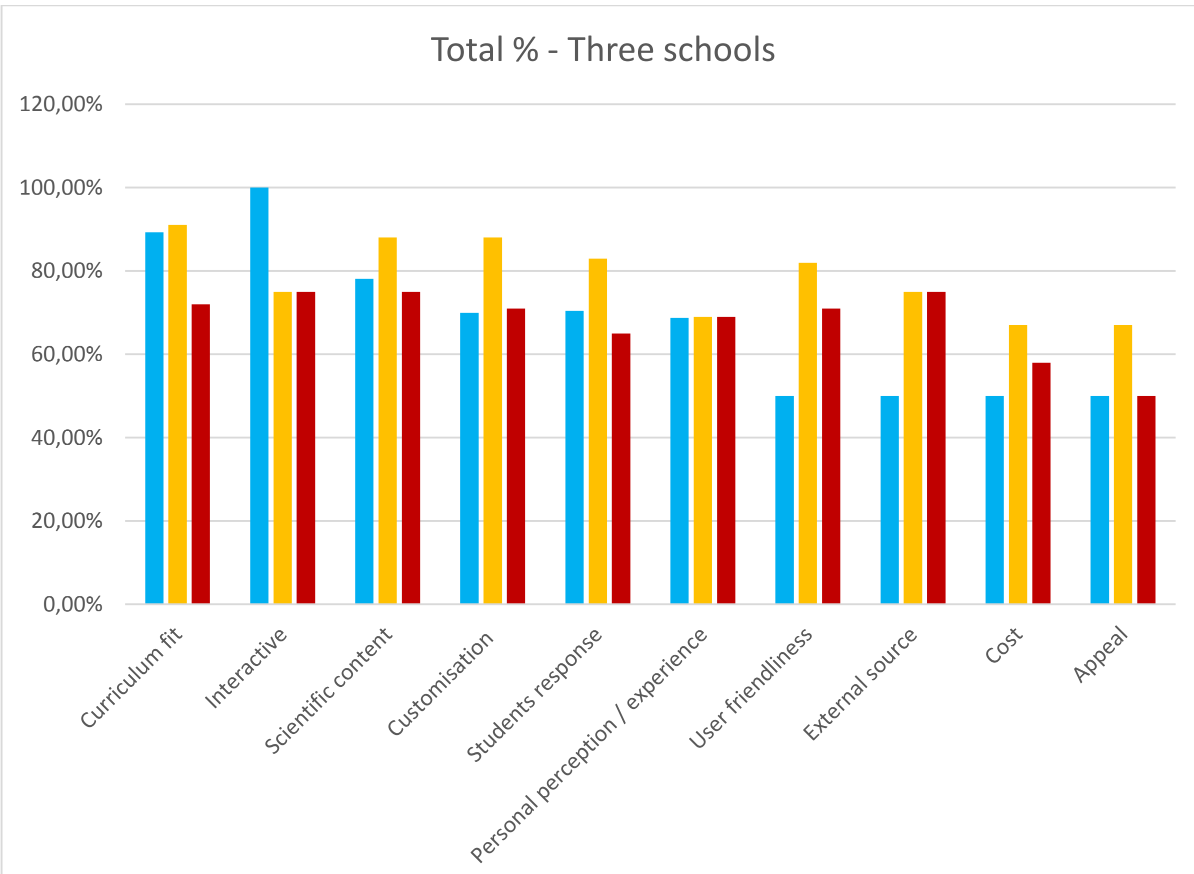


Figure 5-4: Comparing results from all three candidates (source: The Researcher)

All three schools' considered the following factors as one of their top six factors as seen in figure 5-4 above:

1.) Interactive (A: 100%; B: 75% & C: 75%)
2.) Curriculum fit (A: 89.29%; B: 91% & C: 72%)
3.) Scientific content (A: 78%; B: 88% & C: 75%)
4.) Customisation (A: 70%; B: 88% & C: 71%)

5.4.2 Inquiry-based findings

To further investigate teachers' understanding related to inquiry-based teaching, we framed several interview questions around aspects of the essential features of inquiry-based teaching we anticipated that might be common in instruction. We analysed these questions to determine whether teachers were using the features of inquiry-based teaching, even if they were not aware or able to articulate the nature of their instruction.

By analysing the classroom observations and descriptions of the lessons we found some range of instructional practices related to the aspects of inquiry-based teaching. This was not surprising given the different backgrounds of the teachers involved in the study. The educator who demonstrated an ability to best teach with inquiry had had science research experience and had been teaching for a longer number of years and knew her science content very well.

Analysis of the questions revealed that inquiry-based teaching was not common in most of teachers' instruction, and when it was present it was normally teacher-directed or structured inquiry. Teachers separated the act of using technology or apps and employing inquiry-based teaching, we hoped to see the two functions being linked or even inseparable. Only Candidate A explained that when using apps the main teaching strategy underpinning lessons are inquiry-based teaching.

When analysing the data, we established a link between teachers' views and how they taught science. We found that teachers with more robust views were more likely to teach science as inquiry and this links to the fact that teachers' knowledge affects their classroom practice (Cochram-Smith & Lytle, 1999).

Teaching science using inquiry-based teaching is not easy to do and previous research has identified factors that might restrict the educator from using inquiry-based teaching. Some of these factors are: 1.) A lack of time (Abell & Roth, 1992); 2.) Financial impacts (Abell & Roth, 1992; Ginns & Watter, 1995); 3.) A lack of administrative or management support (Lee & Houseal, 2003) and 4.) Classroom management issues (Roehrig & Luft, 2004).

We found very little evidence of inquiry-based teaching practices even though educators referred to inquiry-based teaching practices in their interviews. Educators referred to the strategy but struggled to explain the concept or demonstrate a lesson where they employed the skills; which suggests a disconnection between teachers' views of inquiry and their practice.

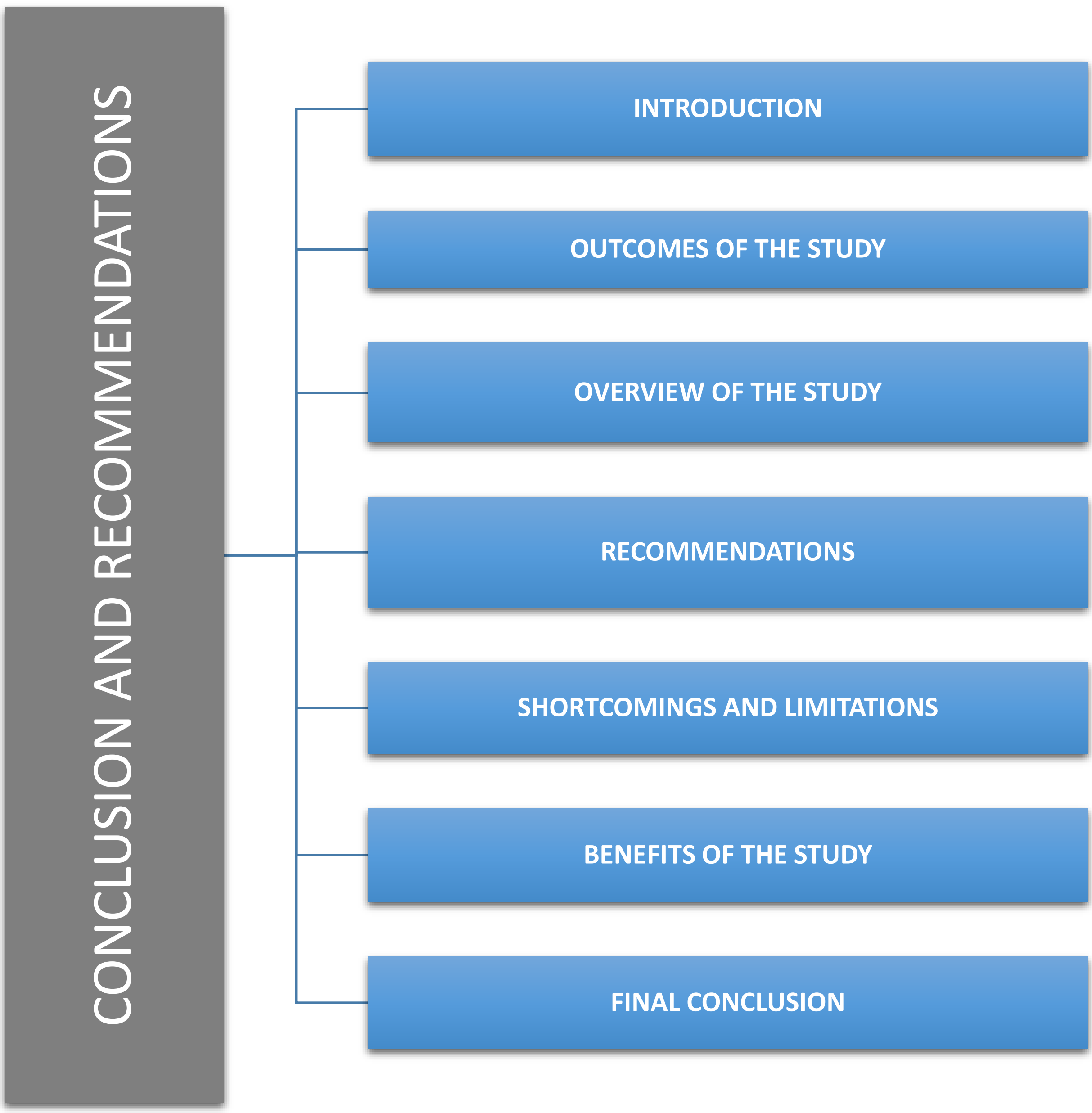
5.5 CONCLUSION

This chapter has built on the findings to select apps that could support inquiry-based science teaching in the FET phase. The responses from all three cases were presented individually. The responses from each cases interview, observation and questionnaire were compared and summarised.

The final chapter presents a comparison between the three cases and present the proposed guidelines to employ when selecting apps to support inquiry-based science teaching in the FET phase. The final chapter also presents a summary and recommendations for future studies on the same topic and a brief discussion of research questions answered by means of the study.

6. CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

Map of Chapter 6: CONCLUSION AND RECOMMENDATIONS



6.1 INTRODUCTION

The previous chapter discussed the data collected and firstly made a case-by-case analysis, then a cross-case analysis to draw conclusions based on a comparison between the three cases. The final product, the proposed guidelines, was developed after a holistic-case analysis had been conducted, comparing each case, including all the data collection instruments' results. A list of proposed guidelines was identified by comparing the data collected from the literature review, interviews, observations and questionnaires.

In this final chapter, the research is briefly summarised with reference to the research questions. The proposed guidelines that were identified (*cf*. Table 2-2) are briefly overviewed and a reflection that leads to recommendations for further studies follows.

6.2 OUTCOMES OF THE STUDY

The main research question and factors acknowledged by the research study was compared in an aim to answer the main research question:

'How do the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?'

In table 6-1 below, we can see a comparison between the factors proposed by the literature review and factors highlighted by the research (*cf.* Table 2-2 and Table 2-3).

Table 6-1: Comparison between factors identified by candidates and further supporting literature (source: The Researcher)

Proposed factors from literature studies	Proposed factors from research (*cf.* Section 5.4.1 and Figure 5-4)
Assessment tools and activities are current (Anderson, 2007); based on a conceptual framework that connects scientific disciplines and themes (Anderson, 2007); intention to fit to the scientific framework (Capps & Crawford, 2013); and less theory teaching (Anderson, 2007)	1. Curriculum fit (84%)
Active involvement of students (Bahru, 2010); hands-on learning (Bahru, 2010); Active activities (Bahru, 2010); actively constructing and finding meaning (Anderson, 2007); discovering of knowledge (Bahru, 2010); teaching skills to fit inquiry-based learning (Capps & Crawford, 2013)	2. Interactive (83%)
Experiments (Bahru, 2010); scientific method (Bahru, 2010); the skill to inquire about science (Anderson, 2007); based on a conceptual framework that connect scientific disciplines and themes (Anderson, 2007); individual understanding are dependent on the person and context (Anderson, 2007)	3. Scientific content (80%)
Ability to inquiry on a personal level (Anderson, 2007)	4. Customisation (76%)
Approach/skills to discover knowledge (Bahru, 2010); students can connect knowledge to a larger body of themes and concepts (Anderson, 2007); prior knowledge may affect the learning process (Anderson, 2007); individual understanding is dependent on the person and context (Anderson, 2007); formulate own questions and later explanations (Minner *et al*., 2010); the challenge is welcomed by able and capable students (Anderson, 2007)	5. Students' response (73%)
Revise method and material to ensure effectiveness (Anderson, 2007); meaning is affected by the influence of society (Anderson, 2007); skill to analyse personal understanding (Minner *et al*., 2010); construct personal framework of understanding (Bahru, 2010); own abilities (Capps & Crawford, 2013)	6. Personal perception or experience (69%)
Sufficient time (Anderson, 2007)	7. User-friendliness (68%)

These findings as summarised above in table 6-1 are in order of importance:

Factor 1: Curriculum fit

Anderson (2007) and Capps and Crawford (2013) propose that inquiry-based teaching will support activities that are current and matched to the curriculum. They go on to explain that activities, experiments and practical tasks are best taught with the help from inquiry-based teaching (Anderson, 2007).

One important aspect that matches both the literature study and the results from the research is that inquiry-based learning as well as apps should fit a scientific framework and scientific discipline or themes.

Factor 2: Interactive

Inquiry-based teaching will involve active learners who are constructing and finding meaning (Bahru, 2010). Capps and Crawford (2013) propose that teaching should fit the inquiry-based learning principles.

Interactive activities, lessons, apps and teaching strategies are all suggested by the research and literature study conducted.

Factor 3: Scientific content

Scientific content involves both those factors that are highlighted by the literature review and research. Experiments and individual activities that match the scientific content at hand (Bahru, 2010 & Anderson, 2007).

Factor 4: Customisation

The ability to search and find meaning of content on a personal level, so that knowledge can be constructed by each individual (Anderson, 2007).

Factor 5: Learners' responses

Learners should be able to connect knowledge to a previous or larger body of knowledge (Bahru, 2010) and link concepts (Anderson, 2007). Individual understanding is influenced by the individuals' experiences and context (Anderson, 2007). Learners are able to construct their own questions, explanations and knowledge (Minner *et al*., 2010).

Both the literature review and the data compared showed that the learners' response to teaching and material used should be considered as they should be able to utilise it and draw meaning form it.

Other factors were also highlighted, but not as frequent as the first five factors mentioned above. These factors were presented both in the literature review on inquiry-based teaching and the principles (*cf.* Table 2-3) that underline the teaching strategy as well as the data comparison between the three case studies (*cf.* Figure 5-4).

These factors could then be used to select mobile educational applications to support inquiry-based teaching in science in the FET phase. The proposed factors that could be used by educators to select apps that could support the inquiry-based science teaching in the FET phase are presented below:

Proposed guidelines to select mobile educational applications to support inquiry-based teaching in science in the FET phase:

1. Curriculum fit
2. Interactive
3. Scientific content
4. Customisation
5. Learners' responses
6. Personal perception and experience
7. User friendliness
8. External sources
9. Cost
10. Appeal

6.3 OVERVIEW OF THE STUDY

This study explored the problem of selecting resources to accommodate 21st century learners (*cf.* Section 1.3.1). The research objective (*cf*. Section 1.2.4) was to identify a proposed set of guidelines that could be used to select appropriate apps for science lessons to support inquiry-based teaching in the FET phase. Five outcomes (*cf.* Figure 1-1) aided the research to reach the final product, a set of guidelines used by educators to select apps. To aid this investigation three cases were interviewed, observed and questioned in their environment or 'context' as referred by the TPACK framework (*cf*. Figure 3-8). The research was conducted at three schools, each handled as an individual case, contributing equally to the study.

The literature review (*cf. C*hapter 2) explored the education system fit for a 21st century learner, the education system in South Africa, especially in science. Teaching styles to accommodate the 21st century learner were further explained and how the resource selection affects how the 21st learner will perform. The literature review also searched for 'factors' (*cf.* Table 2-2) considered by education specialists, either educators or developers, when designing, selecting or implementing new resources for a specific subject. The literature further searched for teaching styles to support science teaching and finally summarised 'principles' (*cf.* Table 2-3) to support the inquiry-based teaching.

The factors and principles were used to design the data-collection instruments (*cf.* Appendix A, Appendix B and Appendix C). Making sure the TPACK framework was used to guide the type of questions asked to address the various knowledge components proposed by the framework (*cf.* Section 3.5; Table 3-8; Table 3-9 and Table 3-10). Three case studies were conducted to compare how three educators from three different educational models select and use apps to enhance inquiry-based science teaching. All three of the cases which were investigated had to comply with the following criteria: educators who are using tablets to enhance and support their teaching; educators should be using apps to assist with science teaching and educators had to teach science at a secondary school level (*cf.* Section 3.6). Semi-structured interviews, observation and questionnaires were used to gain insight into how and why educators selected certain apps to support their teaching in the FET science classroom.

The main research question that the study aimed to answer was:

'How do the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?'

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

- Sub-question 1. What determines the preferred selection of specific mobile educational applications for Physical Science teachers?
- Sub-question 2. How can the use of these mobile educational applications support inquiry-based teaching?
- Sub-question 3. How can mobile educational applications support inquiry-based teaching in Physical Science in a rural and urban contexts in South Africa?

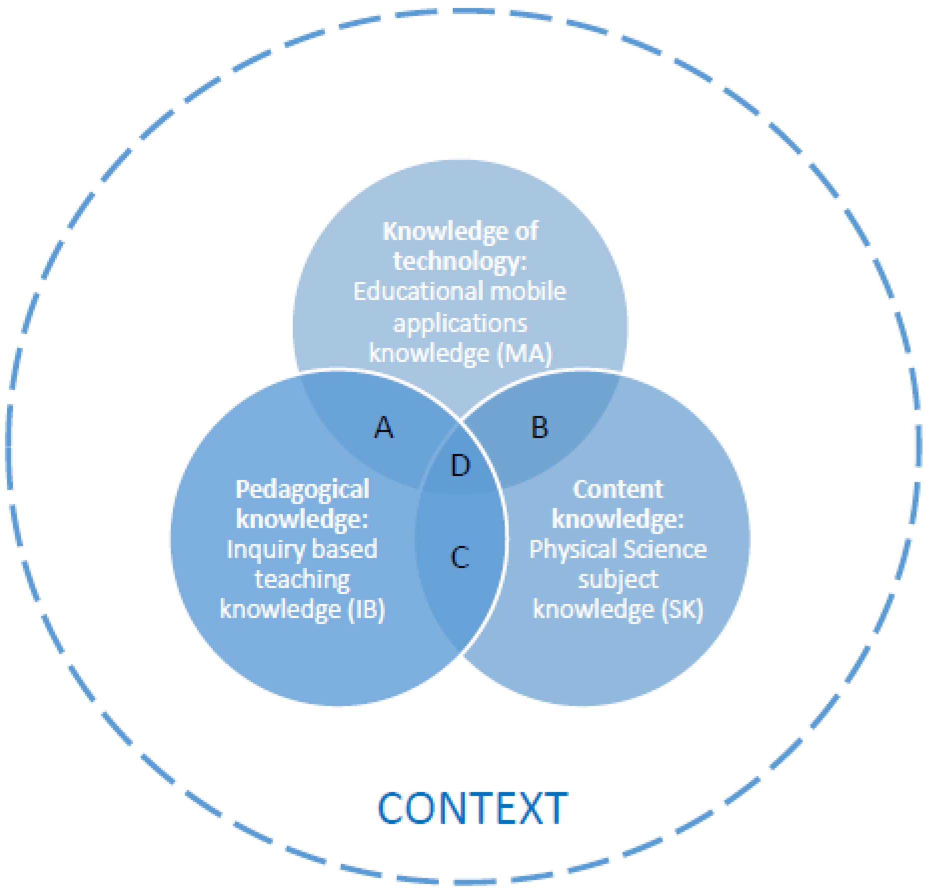
The three questions were addressed in the following manner as seen in table 6-1 below as well. The main research question was addressed by completing a comprehensive literature review searching for 'factors' that developers use when developing new resources and educators use to select resources for their subject field. The literature was also used to search for 'principles' that support inquiry-based teaching styles. The main research question was further investigated by asking specific questions in the interview and questionnaire, as seen below in table 6-2.

Table 6-2: Instruments used to address research questions (source: The Researcher)

Research question	Data instrument			
	Literature review	Interview	Observation	Questionnaire
Main research question: *How does the selection and use of mobile educational applications support inquiry-based teaching in science in the FET phase?*	Searched for literature to provide factors used when selecting and using educational resources that could support inquiry-based teaching in the FET phase (*cf*. Table 2-3).	X	X	X
SQ1: What determines the preferred selection of specific mobile educational applications for science teachers?	Searched for literature to provide factors that influence the preferred selection of educational resources by science teachers (*cf*. Table 2-2).	X		X
SQ2: How can the use of these mobile educational applications support inquiry-based teaching?		X	Observed the use of apps in an inquiry based science lesson.	
SQ3: How can mobile educational applications support inquiry-based teaching in science in a rural and urban contexts in South Africa?		X	Observe the use of apps to support inquiry-based teaching in rural as well as urban schools.	

As seen above in table 6-2 each instrument used was designed to address the research questions.

The study was directed by the TPACK framework (*cf*. Figure 2-4) adapted from Koehler and Mishra (2009). The questions posed were all designed to gain an understanding about the three knowledge components regarding this study, namely knowledge of educational mobile applications; knowledge of inquiry-based teaching and knowledge of Physical Science as seen below in figure 6-1.



A: Interaction between educational mobile apps and inquiry-based teaching

B: Interaction between educational mobile apps and physical science

C: Interaction between physical science and inquiry-based teaching

D: Interaction between all components: educational mobile applications, Physical science and inquiry-based teaching in the specific context

FIGURE 6-1: Adapted TPACK framework and its knowledge components (source: Adapted from Koehler & Mishra, 2009)

As seen above in figure 6-1, three knowledge components directed the questions designed. A proposed set of guidelines was suggested after the three cases had been compared to each other with the help of data coding and hermeneutic principles (*cf.* Section 3.8.1) for conducting and analysing interpretive research (Klein & Myers, 1999). The proposed guidelines to select apps to support inquiry-based teaching in science in the FET phase are set out below in order of importance as found by the three cases.

Proposed guidelines: 1. Curriculum fit; 2. Interactive; 3. Scientific content; 4. Customisation; 5. Learners' responses; 6. Personal perception and experience; 7. User friendliness; 8. External sources; 9. Cost and 10. Appeal.

The findings were well supported by the literature study, but one vital benefit from the study is that these guidelines could be implemented and adapted to fit and support the South African curriculum. This brings us to the following recommendations that could be researched under the same broad theme.

6.4 RECOMMENDATIONS

The following areas can be investigated under the same broad themes:

- South Africa's view of selection guidelines and inquiry-based learning;
- South African apps that support CAPS; and
- Apps designed by teachers for teachers (South African Educational App store/portal)
- A design research to investigate the proposed guidelines to select applications.

6.5 SHORTCOMINGS AND LIMITATIONS

The research was limited to a certain extent by the time available and the scarcity of South African schools using electronic devices in education. The boundaries used to select participants placed a limitation on the participant. The researcher only investigated science educators in the FET phase who are currently using mobile devices to assist in their teaching. This limited the schools that could be selected and as a result some schools were far and made it difficult to visit more than once.

6.6 BENEFITS TO THE FIELD OF STUDY

To ensure the new content is presented to learners effectively, ICT can be an excellent support tool for the transition to a practical curriculum when applied appropriately (Blount & McNeill, 2011;

Grossman, Hammerness & McDonald, 2009). It is argued by Lin *et al*. (2012) that ICT could support inquiry-based teaching by offering curricular resources and materials rather than a traditional approach. According to Harlen and Allende (2009) the fundamental principles of inquiry-based teaching are "...to develop understanding about the scientific aspects of the world around through the development and use of inquiry skills".

It's suggested that inquiry-based teaching is the recommended teaching style used to enhance learners' scientific knowledge skills, and this is also set out by the South African Department of Basic Education (DofE, 2012). Cramer (2007) goes on to explain that educators must reconsider what learning looks like, conclude what the role of the educator is and determine how resources can support effective learning to take place. A very important statement made by Cramer (2007) is that one of the vital roles of a 21st century teacher is the skill to select resources that would enhance effective learning. This brings us to the benefit this study contributed to the field of education in South Africa. The guidelines proposed by this study could direct an educator to select the appropriate resources when teaching science. Addressing the problem of poor education can be done with a sustainable solution.

6.7 FINAL CONCLUSION

The major socio-economic developmental challenges that are faced by most sub-Saharan Africa countries are economic diversity, poverty, unemployment, disease and the unsustainable use of natural resources (Glewwe *et al*., 2011; Van der Berg, 2008). According to Van der Berg (2008) providing better education to citizens has been shown to be one of the ways to effectively alleviate poverty. This study aimed to address one of the problems in education, the resource selection and implementation of resources. Research has been done on selecting the correct resources to support effective learning (McColskey & O'Sullivan, 2000; McCoog, 2008; Currie & Kilfoye, 2010 & Crawford, 2007); however, very little research has been done on educational apps, especially in South Africa, with rather vague or no guidelines available to selecting apps to support an inquiry-based science curriculum.

The research investigated the 'factors' educators employ when searching and implementing new apps during their science lessons in the FET phase and finally addressing the research questions by delivering a set of guidelines.

The right selection of resources would ensure that the correct message is transferred to the right audience using the best available tools according to Chadwick (2012). These guidelines are then presented as a guide for the 21st century teachers among us.

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7. APPENDIX A

7.1 SEMI-STRUCTURED INTERVIEW SCHEDULE

1. How long have you been using apps as part of your science lessons?
2. Has using apps enhanced your lessons in any way? If so, how?
3. Do you find that your learners experience your lessons differently due to the use of apps? Explain.
4. Do you use a tablet or iPad? And why the specific device?
5. Who decided which should be used?
6. Did you get trained on using the tablet or iPad?
7. If ‘yes’, also ask:
   - 7.1. Who trained you?
   - 7.2. What were you trained in?
   - 7.3. When was the last training that you have attended or received?
8. How have your lesson planning changed due to the implementation of apps in your lesson?
9. Which mobile educational applications (apps) do you use?
10. How often do you use the above-mentioned app/s?
11. Why do you use the specific app/s?
12. How do you use the app/s to support your lessons?
13. Is/are there any app/s that you have decided not to use? And why?
14. Have you come across (an) app/s where the subject knowledge is incorrect?
15. Who decides which apps are used in the lessons?
16. How is it decided which app/s to use?
17. What should be considered when designing educational apps for science? (For example colour, length, etc.).
18. Have you experienced any problems with using app/s in lessons? If so, is there someone who can assist you?
19. Are you aware of inquiry-based teaching as a teaching style?
20. If so, do you use your knowledge of inquiry-based teaching when using apps?
21. Would you encourage other educators to also use apps as resources and why?
22. How is using apps in teaching different from using other resources?
23. What don’t you like about using tablet or iPads as resources? What do you wish you could change?

8. APPENDIX B

8.1 OBSERVATION SCHEDULE

Date:
Location:
Background:

Component	Occurrence	Time stamp	Comment
Apps used.			
Apps used without error or hesitance.			
Types of app/s used in lesson			
Role apps play during the lesson.			
How apps are used during the lesson.			
Inquiry-based teaching occurring.			
App/s used to support inquiry-based teaching.			
Other			

9. APPENDIX C

9.1 QUESTIONNAIRE

1. How important do you consider the following aspects to be when you decide which app to download **(use a cross to indicate your preference)**.

	Most important	Very important	I consider it	Don't care
Easy to use				
Cost				
Someone told me about the app				
Funky				
New or desirable features				
Scientifically correct				
Curriculum related				

2. How skilled are you on electronic devices, especially your tablet/ipad? **(Use a cross to indicate your preference)**

I am a PRO | 1 2 3 4 5 | I am a LEARNER

3. When using apps for a learning task, how important are the following in getting the job done? **(use a cross to indicate your preference)**

	Most important	Very important	I consider it	Don't care
My expectations				
The time it takes				
My skills level				
My enjoyment				
The learners' enjoyment				
My mood				
My motivation				
The learners' results				
Previous success				

4. Tell us about **why** you use apps in your lessons (use a cross to indicate your preference).

	Strongly agree	Agree	Disagree	Strongly disagree
It is convenient				
I am in control of the technology				
It is familiar to me				
It is a fashion statement				
It supports the students' understanding				
Learners' response				
Curriculum related				

5. Tell us about **how** you use apps in your lessons (use a cross to indicate your preference).

	Almost always	Mostly	Sometimes	Almost never
To draw learners' attention				
To introduce a new concept				
To demonstrate concepts				
To keep lessons interesting				

6. How important is the following information for an app? (Use a cross to indicate your preference).

	Most important	Very important	Should be considered	Not important
The information should be relevant				
The information should be given in small sections				
The information should be available to the learners as well				
The information should be colourful				
The information should be able to download to use later				
The information should be cheap to access				
The information should encourage learners to think for themselves				
The information should pose other questions with the learners				

	Most important	Very important	Should be considered	Not important
The information is current and up to date				
The information should be South African				
The information should be developed by educational specialists				
The app must meet the requirements of all the learners in the class				
The app should indicate for what age the information is appropriate				
Technical performance				

7.1. How is using apps for educational purposes different than using apps for entertainment?

....

....

7.2. What do you like about apps for educational purposes?

....

....

7.3. What don't you like about apps for educational purposes?

....

....

7.4. What would you change about apps used for education?

....

....

8. Would you recommend other educators to use apps when teaching science? (use a cross to indicate your preference)

1. Most definitely	2. Certainly	3. It won't do any harm	4. It is up to them	5. Not at all.

9. How do apps enable you to do something you were unable to do in the past?

....

....

10. How do apps support science education? (Use a cross to indicate your preference).

	Strongly agree	Agree	Disagree	Strongly disagree
Students are more interested in Science				
Students understand concepts better				
Students grasp complex concepts better				
I am more motivated to teach Science				

11. Any other information you would like to bring to our attention?

....

....

10. APPENDIX D

10.1 ETHICS AND PERMISSION

10.1.1 Letter to principal

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

The Principal
School name
Town

Date

Request for Permission to Conduct Research

I am a Masters student in the Department of Science Mathematics and Technology Education at the University of Pretoria. I work on a project that is supervised by Doctor Ronel Callaghan, lecturer in the Faculty of Education and Professor Marlien Herselman, researcher at the CSIR's Meraka Institute and would like to ask permission to collect data at your school.

The project is entitled '**Mobile educational applications that support inquiry-based science teaching in South Africa'.** It explores how science educators select mobile educational applications (apps) and use these resources to support learners understanding. The project forms part of a study done with the help of the CSIR, where the Department of Education in the Eastern Cape gave permission for schools to participate in the study.

Participating in the project may benefit the school in the sense that the educator involved, may become increasingly aware of the mobile application selection process and the importance of addressing the process when planning their lessons. This may lead to improvement of learners' conceptual understanding of the work.

The research will not disrupt learning in any way, since learners are not involved. Only one FET science educator will be required to complete a semi-structured interview and a questionnaire after school hours. The researcher would observe the educator in lessons as arranged by the educator and the researcher. Only field notes will be made by the researcher during the observations, therefore no students will be interviewed or videotaped. During the observation the researcher will focus on the teaching process and the use of mobile educational applications (apps) in the classroom. All information will be treated anonymously when reporting results. The identity of teachers and participating schools will be strictly confidential.

Your positive consideration in allowing one of your teachers to participate in this project will be highly appreciated. Should you agree, please read and sign the document of informed consent attached to this letter. Thank you very much for spending time to consider this request.

Kind regards,

Signed: ....
Mrs M. Moolman
Masters Student

Signed: ....
Dr R. Callaghan
Lecturer and supervisor

Signed: ....
Prof B. Fraser
HOD

Informed consent by Principal to allow data collection for a research project

With reference to the letter of information about the research project entitled "**Selection and use of mobile educational applications that support inquiry-based Physical Science teaching',** please read the conditions below and sign if you agree that your school may participate.

I understand and agree that:
1. The data collection will not disrupt the normal teaching and learning activities.
2. Information will be used only for research purposes.
3. The school and the teachers' anonymity will be maintained and no comments will be ascribed to the school or the teachers' by name in any written document or verbal presentation. Nor will any data be used from the interview, questionnaire or observations that might identify the school or teacher to a third party.
4. The teacher will be required to complete a questionnaire and be interviewed for about 30 minutes after school. The teacher will also be required to be observed during lessons at a time suitable for the teacher.
5. Learners will not be observed or tested for this project.
6. This school's participation in the project is voluntary, and the school can withdraw at any stage.
7. I am not waiving any human or legal rights by agreeing to participate in this study.
8. The researcher will write to you on completion of the research project and a copy of the final research project will be made available to you upon request.
9. I verify, by signing below, that I have read and understood the conditions listed above.

Schools' name and stamp: ______________________________

Principal's name: ____________________ **Signature:** ____________________

Place: ____________________ **Date:** ____________________

Student's name: ______________________________

Signature: ____________________ **Student number:** ____________________

Place: ____________________ **Date:** ____________________

Supervisor's name: ____________________ **Signature:** ____________________

Place: ____________________ **Date:** ____________________

10.1.2 Letter to participant

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

To: FET Science teachers at selected schools

Informed consent to participate in a research project

You are hereby invited to participate in a research project conducted by a Masters student from the Department of Science Mathematics and Technology Education at the University of Pretoria. The project is supervised by Doctor Ronel Callaghan, lecturer in the Faculty of Education and Professor Marlien Herselman, researcher at the CSIR's Meraka Institute.

The project explores the process that Science teachers follow to select mobile educational applications (apps) used in Science teaching. Science teachers are asked to participate because they have first-hand experience of selecting appropriate resources for their lessons and learners.

I was wondering if you would be agreeable to participate in this research. You will be required to participate in the following activities:

Activity	**Time required**
Interview	less than 30 minutes
Observation	On times suitable and arranged by the teacher
Questionnaire	Less than 20 minutes

We do not anticipate any risk by participating in this study, instead we foresee that the results will increase your understanding in the process followed to select mobile educational applications (apps) that could support Physical Science teaching. The results of this study may be used for a research report and a journal article. Your identity will not be disclosed and all detail regarding your school and yourself will be handled as strictly confidential. No names of you or your school would be provided in any publication or public presentation to ensure anonymity.

The principal gave permission for this study to be conducted at this school. However, your participation in this project is completely voluntary, and you are free to withdraw at any time and for any reason without penalty. Your choice to participate or not will not impact your job or status of the school. You are also free to refuse to answer any particular questions you do not wish to answer.

Declaration on informed consent

I have read and I understand the above information. I voluntarily agree to participate in the research project described above. I do agree to complete the questionnaire and to have the interview and observation audio taped for the purposes of transcription.

………………………………………… ………………………………

Participant Date

………………………………………… ………………………………

Student Date

………………………………………… ………………………………

Supervisor Date

If you have any questions about this research; please contact Dr R. Callaghan (supervisor) by telephone at (012) 420-5521 or by e-mail at ronel.callaghan@up.co.za.