Paperless classroom experiences in Grade 7 Science in township schools by

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Submitted in partial fulfillment of the requirements for the degree in

Magister Educationis (General)

University of Pretoria

Supervisor: Dr. Ronel Callaghan

Date of submission

February 2019

DECLARATION

" I hereby declare that this document: **Paperless classroom experiences in Grade 7 Science in township schools**, submitted for evaluation towards the requirements of the MEd General at the University of Pretoria, is my own original work and has not previously been submitted to this, or any other institution of higher learning or subject for evaluation. All sources used or quoted in this document are indicated and acknowledged by means of a comprehensive list of references".

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ETHICAL CLEARANCE CERTIFICATE

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RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	CLEARANCE NUMBER: **SM 16/11/01**
DEGREE AND PROJECT	MEd Paperless classroom experiences in Grade 7 science in township schools
INVESTIGATOR	Ms Victoria Nomcebo Makwela
DEPARTMENT	Science, Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	8 February 2017
DATE OF CLEARANCE CERTIFICATE	04 October 2017

CHAIRPERSON OF ETHICS COMMITTEE: Prof Liesel Ebersöhn

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Ms Bronwynne Swarts
Dr Ronel Callaghan

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

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

ABSTRACT

This study aimed to explore how ICT supports the learning and teaching of Science in Grade 7 of two schools in Tembisa that are currently piloting Paperless classrooms. The research sought to describe the experiences of the teachers and learners, during the teaching and learning of Grade 7 natural science in the schools. In this study, the population is 180 Grade 7 learners in Science classes, three teachers, the principals, and the ICT co-ordinators of both schools. This research followed an interpretive and qualitative approach. The research strategy was a descriptive case study of the two schools, each as a case. The conceptual framework of the study was based on the Technology, Pedagogy and Content Knowledge (TPACK) framework. The data collection instruments were interviews, focus groups discussions, classroom observations and questionnaires.

The data that was collected showed that all aspects of TPACK are important for successful integration of ICT. According to the findings, the experience of teachers and learners in the Paperless project is good, even though there are challenges. Learners felt motivated by using technology while learning. Teachers needed more training and support in integration. They viewed integration as good practice if the challenges they came across could be attended to by schools' leadership and the Gauteng Department of Education.

LANGUAGE EDITOR'S DISCLAIMER

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TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled ***"Paperless classroom experiences in Grade 7 Science in township schools "*** *by Victoria Nomcebo Makwela was proof read and edited by me in respect of language.*

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Kind regards

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DEDICATION

This dissertation is wholeheartedly dedicated to my lovely family, my husband Peter Makwela and my children Musa, Katlego, Karabo and Tebogo for their support and understanding when I was not there for them because of my studies. It was not easy, but it was worth it.

Finally, I dedicate this dissertation to Almighty God who has always been with me through the good times and the bad times. He provided me with wisdom, grace, creativity and strength to continue successfully during my course work. Glory be unto Him.

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LIST OF ABBREVIATIONS

CAPS: Curriculum and Assessment Policy Statement

CEO: Chief Executive Office

DBE: Department of Basic Education

DoE: Department of Education

E-Education: electronic education

E-Learning: electronic learning

EN: Ekurhuleni North

E-School: electronic school

GDE: Gauteng Department of Education

GoL: Gauteng Online

ICT: Information and Communication Technology

NCS: National Curriculum Statement

NEPAD: New Partnership for Africa`s Development

OBE: Outcome-Based Education

RNCS: Revised National Curriculum Statement

SGB: School Governing Body

TAM: Technology Acceptable Model

TIMSS: Trends in International Mathematics and Science Study

TRA: Theory of Reasoned Action

TPACK: Technological Pedagogical Content Knowledge

LIST OF CONCEPTS

Attitude towards science - the development of interests in science and science-related activities and an interest in pursuing a career in science or science-related work (Osborne, Simon, & Collins, 2003, p. 87).

Curriculum - a programme of study in a school.

Implementation - to put a set of activities into practice.

Integration - the use of technology in communication.

Integration in teaching and learning - (Polly & Hannafin, 2011, p. 863), view integration as instances in which teachers and/or learners use technology as a tool to support the learning process.

Natural science - Natural science is a systematic way of looking for explanations and connecting the ideas we have by formulating a hypothesis, designing, carrying out experiments to test the hypothesis (Department of Basic Education, 2011, p. 8).

Phenomenon – occurrence or circumstance observed or observable.

Population - a collection of individuals or objects.

Support learning - Using different resources (DVDs, Audiotapes, and physical teaching aids) during teaching and learning.

Technology in education - the use of knowledge, skills, values, and resources to meet peoples' needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration (Department of Basic Education, 2011, p. 8).

Wi-Fi - a technology that uses radio waves to provide network connectivity.

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1. Background and orientation

1.1. Introduction

Worldwide, Information Communication Technology (ICT) is regarded as a panacea for educational ills (Ayas, 2006; Baytak, Tarman, & Ayas, 2011; Yonazi, Kelly, Halewood, & Blackman, 2012). ICT is believed to introduce change and promote the skills necessary for the economic development of countries (Alam & Mahabubi, 2009). Whilst conventional 'chalk and talk' pedagogies are increasingly being replaced by new ICT in classrooms, learning is made more interesting, enjoyable and interactive. As a development of the integration of ICT into education, teaching is evolving from instructing into facilitating the dissemination of knowledge to learners (Craddler, McNabb, Freeman, & Burchett, 2002). As learners are empowered with the mobile technology, they become enriched with self–regulated learning (Mueller, Wood, Pasquale, & Archer, 2011). Learners generally prefer to learn through discovery and interaction (Baytak et al., 2011). Innovations in technology are anticipated to reduce the high learners' failure rate by increasing the deeper understanding of abstract concepts (Draper, 2010; Kazeni, 2012; Polly, Mims, Sherpherd, & Inan, 2009; William & Kyle, 2006).

ICT influences and further improves the quality of the learning environment, motivation, scholastic performances and teaching and learning processes (Harris, GRUBB III, & Hebert, 2005). Researchers are finding that lack of interest and motivation in science subjects is partly responsible for the high science failure rate (Learningenglish, 2016; Motshekga, 2016). In support of the preceding arguments, Kazeni (2012) opines that learners' interest in science-related subjects is declining because of poor performance. Researchers Yonazi, Kelly, Halewood and Blackman (2012) insist that there is adequate evidence that ICT can improve learners' achievement and performance.

The root causes of learners' failures in South Africa are not fully understood. It is difficult to change a situation of you do not understand the underlying factors – and research can support this process of discovering the truth about our world (Birley, 1996).

This chapter provides the background to the research, introduces the problem statement, research questions and the background and objectives in respect of the experiences of teachers and learners in Grade 7 Sciences in this study.

Some of the elements which contribute to the effectiveness of ICT integration which were researched in this study are attitudes of educators and learners, challenges faced by teachers and learners, mobile technology supporting self-regulated learning and impacts of integration.

1.2. Background

It is globally accepted that the integration of ICT in education improves learners' performance (Earle, 2002). The impacts of ICT in education are many and varied. For example, ICT is perceived as an important element contributing to improvements in performance, collaboration and learning experiences and outcomes (S. Albugami & V. Ahmed, 2015). Research indicates that technology use in classrooms impacts positively on learners' attitude, engagement and achievement (Butzini, 2001). Technology enriched environments can affect learners' achievement, self-esteem, and classroom interactions. In most researches the impact of ICT on learners is positive. These attempts to improve education through enriching learners and educators have been found to be sustainable even in the introduction of newer, very portable handheld devices. These mobile technologies are starting to show potential in teaching and learning within the classroom and beyond (Mueller et al., 2011).

However, the integration of ICT in some countries as well as in South Africa is hindered by a number of issues such as the high student failure rates (Learningenglish, 2016; Motshekga, 2016). Due to the wide acceptance of mobile technology in the country, especially among the young, South Africa is pioneering projects that make use of mobile technology (tablets and smartboards) for example in Tembisa and the Western Cape Province (Du Bois & Chigona, 2018; Khumalo, 2016; Kouassi & Hurst-Harosh, 2018; Mwangi, 2017) for learning, hoping that the issue of high failure rate would consequently be addressed.

In order to assess whether mobile technologies in the piloted area have indeed contributed to self-regulated collaborative learning and increased knowledge

construction, while leading to improved learner motivation and satisfaction, evaluations are needed, along with learners' achievement levels (Lai, Yang, Cheri, & Chan, 2007).

This research focus on two of the pilot schools in the Paperless Classroom project, as initiated by the Gauteng MEC for Education. Classrooms were equipped with the latest technology for teaching and learning. The project was funded and supported by the Gauteng Department of Education. Smartboards are installed in the classrooms and teachers were provided with laptops and learners received tablets. The schools also have strong Wi-Fi. Teachers had been trained and are still receiving training on the usage of Smartboard for teaching and learning. Each school has been allocated security personnel and interns to provide technical support.

This research explored experiences of ICT integration in Grade 7 Science teaching and learning. This research explored which key success factors were responsible for the effectiveness of ICT, that is, which factors fostered positive or negative teacher and learner outcomes.

1.3. Research focus

The objective of this study is to investigate the implementation of Paperless Classrooms in the teaching and learning of Science in two primary schools in a township. It is to study the attitudes, challenges, and benefits of teachers and learners during ICT integration in teaching and learning Natural Sciences in Grade 7.

For the purpose of this study, the researcher will refer to Science for Natural Science throughout the study.

1.3.1. Problem statement

Despite the numerous ICT benefits in education as stated in the previous sections, some countries around the world, including South Africa, are faced with the fate of high learners' failure rates, more so in mathematics and sciences (Learningenglish, 2016; Motshekga, 2016). Consequently, learners are dropping out of schools because of failing to meet the minimum required pass rate to proceed to the next class level. The poor performance has the repeating negative effect that is affecting the

employment world, because of the shortage of rightful skills, among other things, the South African unemployment rate has reached the 25% mark.

Lack of motivation in the classrooms by the learners is a contributory factor to the poor performance leading to the lack of interest in subjects such as science (Alam & Mahabubi, 2009; Krapp & Prenzel, 2011). A lack of connection between education and real-life situations is a major factor responsible for learners' demotivation (Fu, 2013; Morsink et al., 2011; Smaldino, Lowther, Russell, & Mims, 2008; van Weert & Tatnall, 2005).

Furthermore, researchers indicate that teachers' quality is negatively correlated with the learners' performance (Akinfe, Olofinniyi, & Fashiku, 2012; Burns, 2012). The vision to move from instructional teaching to learner-centered teaching is often absent (Krapp & Prenzel, 2011). This research seeks to explore as to whether the implementation of ICT is supporting teaching and learning as per the constructivist theory. The data was collected through answering the research questions posed to the participants. It is needless to emphasize the importance of effectiveness of ICT as supported by Newhouse (2002) who asserts that educational technology should be used effectively or not at all.

1.3.2. Research questions

Primary question

What are the experiences of teachers and learners in Grade 7 Science in township schools in the Paperless project?

Secondary questions

1. How is the ICT integration into the Grade 7 Science classroom in the Paperless classroom project?
2. Which challenges did the participants experience during implementation?
3. How did the implementation benefit the teaching and learning processes?

1.3.3. Rationale

Worldwide, the integration of ICT in education is seen as a major resource for effecting necessary changes (content, pedagogy, and outcomes) in the conventional teaching

and learning process, as presented by the existing literature in chapter 2 of the current research (Newhouse, 2002). However, the implementation of ICT in the educational curriculum is oppressed with numerous problems, among others, the high failure rate of ICT implementation. There is, therefore, a need to understand the factors involved in the effective integration of ICT to reduce the high failure rate, that is, establish how ICT is supporting teaching and learning in the pilot areas of Tembisa and Western Cape.

The research investigated what factors are responsible for the ineffectiveness of ICT integration. Some of the elements that were researched were the challenges faced during integration; attitudes of teachers and learners and recommendations on challenges that are encountered in ICT implementation.

There only two primary schools where the Paperless classroom project was initiated and only Grade 7 learners are benefiting from the project in Tembisa. Other primary schools were not part of Paper-less classroom project that is been piloted by Gauteng Department of Education in Gauteng. The research was done in only two primary schools.

1.3.4. Purpose of the research

The main purpose of this research is to explore if ICT is indeed supporting learning and teaching of natural science in Grade 7 in township schools where the Paperless project has been initiated. Specifically, based on the above research questions, the research sought to find out:

- How is ICT integration into the Grade 7 Science classroom in the Paperless classroom project?
- Which challenges did the participants experience during implementation?
- How did the implementation benefit the teaching and learning processes?

1.4. Brief literature overview

The literature review reflected is based on the investigations of the present literature of the integration of ICT in education in addition to other factors contributing to

effectiveness internationally as well as in South Africa. The researcher looked at the conventional practices that are taking place in ICT integration and compared them to the ICT impacts that are taking place around the world. The causal powers of the traditional methods of teaching science are that they often contribute to learner failure as they are found to be ineffective (Kazeni, 2012). The researcher looked at critical realist perspective in terms of causal powers and the lack of successful ICT integration due to causal factors in the social and artefactual reality. The unintended outcomes such as unsuccessful integration of ICT in the teaching and learning of science are discussed. Refer to Chapter 2 of this study.

1.5. The theoretical and conceptual framework

The TPACK model in brief

TPACK is the general conceptual framework for this study. TPACK is a technological pedagogical content knowledge framework. TPACK framework is discussed in detail under Section 2.8 in chapter 2 .TPACK is a framework that studies the complex relationships that need to occur “between a teacher’s knowledge of content (CK), Pedagogy (PK), and technology (TK)” (Baran, Chuang, & Thompson, 2011). TPACK refers to a “synthesized form knowledge for the purpose of integrating ICT/educational technology into classroom teaching and learning” (Koh, Chai1, & Tsai, 2013). It is a framework for understanding “the relationship between teachers' knowledge of technology, content knowledge, and knowledge about teaching” (Koh et al., 2013; Morsink et al., 2011)

TPACK has emerged as useful framework to understand technology integration in learning and teaching (Baran et al., 2011). It is being used on an increasing basis to describe the knowledge that teachers need to possess to be able to effectively integrate technology into their pedagogical practices (Schmidt et al., 2014).

1.6. Research Design

The research design is the plan of how to proceed to collect information to address research objectives (Maree, 2013). The research design used in this study is guided by the Onion Model of Saunders, Lewis and Thornhill (2007), refer to Chapter 3 Section 3.3. Figure 1 depicts the research onion. The researcher used the research

onion to explain how the research design of this study followed. Different layers in figure 1 represent fragments of research design (Saunders & Thornhill, 2009).

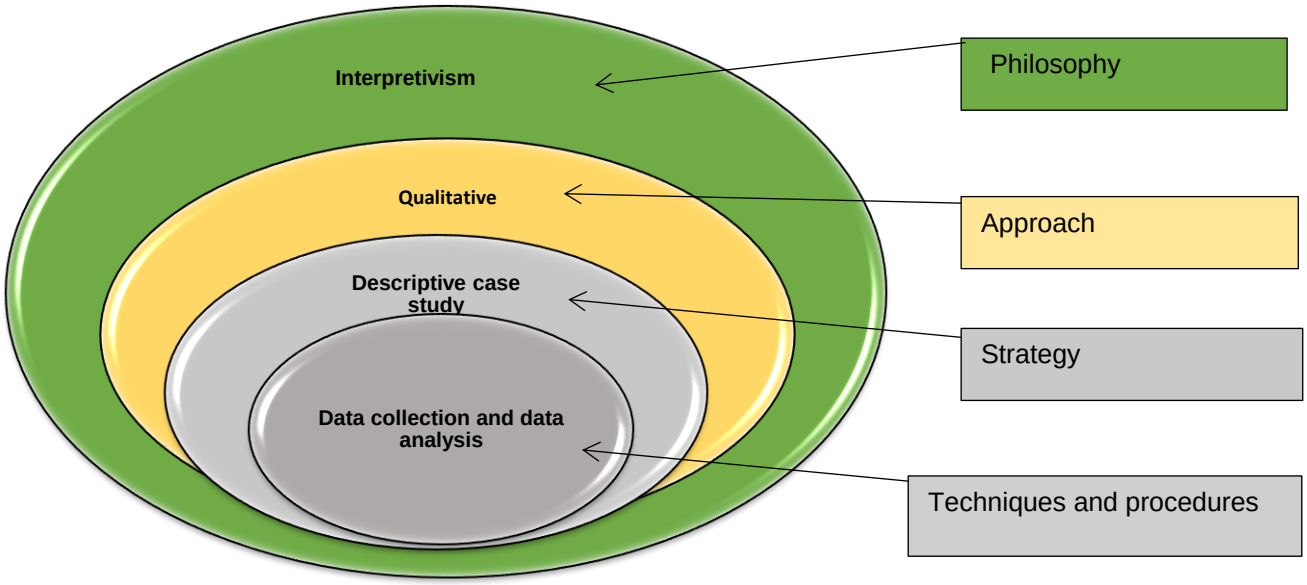

Figure 1: Research onion

Adapted from Saunders et al. 2007

1.6.1. Philosophy: Interpretivism

The research design is Interpretivist (Sefotho, 2016). Interpretivism has roots in hermeneutics, refer to Section 3.6.2 of Chapter 3, the study of the theory and practice of interpretation, "in understanding and interpretation, part and whole are related in a circular way" (Maree, 2013)**.** The philosophy of this study is interpretivism, refer to Section 3.3.1 in Chapter 3. The researcher aimed at getting inside information about two cases.

1.6.2. Approach: Qualitative

A qualitative research approach allows for a researcher to investigate participants in their own environments and to interpret meaning of their responses (Maree, 2013)**.** This study followed a qualitative research approach, refer to Section 3.3.2 of Chapter 3.

1.6.3. Strategy: Descriptive case study

According to Dudovsky, a case study allows for the analysis of aspects in a bounded system (Dudovskiy, 2015; Mwandihamba, 2018). The center of interest of descriptive case study is the wide description of whatever concepts are being researched (Hamilton & Corbett-Whittier, 2013). The strategy that was used in this study was descriptive case study. The aim of the researcher was to describe two cases on how the implementation of ICT was taking place. Two cases were described, refer to Section 3.3.3.2 in Chapter 3.

1.6.4. Population and sampling

The population in this study are all schools that are implementing technology in teaching, and the sample included the two primary schools that formed part of the first implementation of technology in a paperless classroom project. Within these two schools, the sample were the teachers and learners involved in Grade 7 Science (McMillan & Schumacher, 2010). The way in which participants were selected is explained further under Section 3.3.4 in chapter 3.

1.6.5. Data collection

Data was collected via interviews, focus group interviews, observations and questionnaires. The researcher gathered the data by observing Science lessons - using audio recordings**.** For data collection instruments that were used in this study, refer to Section 3.5 in Chapter 3.

1.6.6. Data analysis

Data analysis involves organizing the raw or unprocessed answers from the interviews and developing themes (De Vos, Strydom, Fouche, & Delport, 2014). Data that was generated in this study was analysed, six themes were used from TPACK, refer to Section 3.6 of Chapter 3. The data was processed to provide a quantified representation of the results, to support the discussions of the findings.

1.6.7. Hermeneutics

During data analysis seven hermeneutics principles were considered in this study. Hermeneutics principles help as an approach of analysis related to interpretivism. A

hermeneutics approach suggests a way of understanding the meaning of data (Klein, 1999). This was done to make sure that collected data that was interpreted were the stories from the side of the participants and not the researcher's view, refer to Section 3.6.2, hermeneutics principles.

1.7. Delineations

The research was conducted with Grade 7 learners from two schools in Tembisa, South Africa. Furthermore, when research is conducted in other geographies, specifically rural areas with limited resources, the outcomes might differ. It is recommended that the scope should be increased to cover more geographies, as well as another classroom grade. The two schools are the only primary schools where the Paperless classroom project was initiated and only Grade 7 learners are benefiting from the project. Other primary schools were not part of Paper-less classroom project that is been piloted by the Department of Education. Data collected added much information on what is going on in the schools concerning the study.

1.8. Trustworthiness

Trustworthiness refers to the steps of assurance in data interpretation, analysis, findings and methods used to confirm the researcher's objectiveness during a study. The trustworthiness includes principles like dependability, transferability, credibility, and confirmability (Maree, 2013), refer to Section 3.7.7 of Chapter 3.

1.9. Ethical considerations

Research ethics relates to careful consideration of the rights of the participants in the research (Bull, 2004; Saunders & Thornhill, 2009). The following are the ethical implication of data collection strategies.

The researcher applied for permission from the Gauteng Department of Education to conduct the study at two primary schools in Tembisa. The permission was granted to the researcher to continue with the study, refer to Appendix B. The researcher was granted permission to continue with the study by the Faculty of Education's Ethics Committee. The application was approved on the 8th of February 2017, refer to Appendix B.

Participation was voluntary, no participant was forced to take part in the study. Informed consent was practised by explaining the purpose of the research to participants, confirming that they could end their participation at any time without penalty, and providing a full disclosure of any risk associated with the study. Assent forms were signed by minors. Participants were assured of safety and the participants were assured to trust the researcher in keeping the data safe.

1.10.Chapter outline

CHAPTER 1: INTRODUCTION

This chapter crystallizes an understanding of the problem statement and justifies the research questions and objectives. The definitions that are key to the understanding of terminologies used in the research are clarified.

CHAPTER 2: LITERATURE REVIEW

The chapter delves into the existing literature of the integration of ICT in education as well as the factors for effectiveness internationally and locally. The chapter exposes the TPACK model and its numerous uses.

CHAPTER 3: RESEARCH METHODOLOGY

In this chapter, the survey method adopted to collect data for the research objectives is explained. The research questions and propositions to be confirmed by the research are also set out in this chapter. The techniques applied to justify the research instrument and to validate the research method underpinning the qualitative research techniques are also detailed.

CHAPTER 4: RESULTS AND ANALYSIS

The chapter presents the actual results from the study as collected through the interviews, lesson observations, focus groups and questionnaires.

CHAPTER 5: FINDINGS AND CONCLUSIONS

The findings and conclusions of the research are discussed in the chapter, while recommendations are made concerning further research.

1.11.Conclusion

The aim of Chapter 1 was to provide information about the problem statement and research questions, while the background, objectives and the methods used to address them are discussed. The chapter oriented the reader on the problem

statement, questions and objectives and emphasizes the importance of successful integration strategies which would impact on the future nationwide implementation as the program gets an overall implementation in the rest of the country that is, having taken some learning lessons from the case study areas. The next chapter provides a broad overview of the existing literature on the integration of ICT in education internationally and in South Africa.


Chapter 2
2.1 Introduction
2.2 Generic theories in research
2.3 ICT integration
2.4 Science in grade 7
2.5 ICT integration
Positive aspects
2.6 ICT challenges
2.6.1.International examples
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2.6.2.1 TPD
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2.7 Critical realism
2.8 ICT integrations frameworks
2.9 Conceptual frameworks
2.10 Conclusion

2. Literature Study

2.1. Introduction

The traditional teacher pedagogical beliefs may influence teachers as they use their judgments or voluntarism to integrate or not integrate ICT in Science. Instructivism coerces learners not to be motivated towards learning with technology as they are supposed to be passive whilst the teacher is instructing them. According to instructivist philosophy education is teacher centred, teachers continue teaching their traditional ways and therefore the education system remain teacher centric and not learner-centric (Ertmer, 2005; Sang, Valcke, van Braak, Tondeur, & Zhu, 2010; Tondeur, Valcke, & van Braak, 2008).

As a comparative means to highlight the ineffectiveness of the conventional pedagogical practices, this section discusses the ineffectiveness of the conventional pedagogies. Teachers receive and transmit or instruct information to learners through conventional teaching methods instead of facilitating production of information from the learners using ICT. Most teachers (James, Hesselmark, Akoh, & Mware, 2003) are intimidated by technology and are comfortable with their own teaching styles which involve face to face lecturing with learners having to memorize the contents.

As generative mechanisms from a critical realist perspective have causal powers, the lack of successful ICT integration due to causal factors in the social and artefactual reality often has unintended outcomes such as unsuccessful integration of ICT in the teaching and learning of science, often accounted for by the interactions between the real mechanisms and the events or actual reality. As the realm of social reality is the location of mechanisms such as the rules, ICT implementation guidelines and ICT policies, (Fleetwood & Ackroyd, 2004) conceded that mechanisms interacting within contexts will always yield outcomes often intended or unintended contingent upon the agencies and their voluntarism in the actual realm. That is: *Mechanism + Content= Outcomes*. Choosing to use computers characterized by drill, practice and remediation to support learning and not incorporating them in the curriculum often has dire consequences or outcomes, because teachers with their traditional pedagogical beliefs remain instructivists (or teacher centred) and not constructivists (learner

centred). That is, teachers continue teaching their traditional ways and therefore the education system remain teacher centric and not learner-centric (Ertmer, 2005; Sang et al., 2010; Tondeur et al., 2008).

The review examines the different existing literature reviews and perspectives (causal descriptions) under which technology has been integrated into teaching and learning specifically in Grade 7 schools around the world, around the Africa content and finally in South Africa and Gauteng.

There are key factors contributing to the successful integration of ICT in teaching and learning in education, implying that non-adherence to the integration procedures and principles would culminate in unsuccessful ICT integration. The ICT integration process thus revolves “around the nature of objects and their causal powers” (Danermark, Ekstrom, Jacobsen, & Karlsson, 2006; Fleetwood & Ackroyd, 2004).

Second, the literature review reveals that the successful ICT integration should be viewed in terms of how the integration rules and principles are internalised and interpreted by the teachers and learners as per the value judgment in Section 2.6 (Danermark et al., 2006; McKenzie & Sud, 2008).

Third, it also emerges from the literature review that the implementation and integration of ICT in education would be incomplete without taking into account the broader socio-economic environment as well as the contextual factors (Nkula & Krauss, 2014; Shook, Priem, & McGee, 2003). The literature review on the integration of ICT in teaching and learning commences with the discussion of what is understood as integration around the world. In Africa, and in South Africa the emphasis is on the fact that non-adherence to integration frameworks among others, like TPACK, leads to unsuccessful integration of ICT in education because of ignoring the essential integration factors (Nkula & Krauss, 2014).

2.2. Generic theories in research

According to Aldrich and Martinez (2001) theories serve as interpretive lenses for crystallizing understanding of phenomena. Theory “is a researcher’s attempt to discuss the set of dependence relationships explaining a set of outcomes” (Cooper &

Schindler, 2001; Cooper & Schindler, 2006, p. 193). For this research, the desired outcome is the successful integration of ICT within Gauteng schools offering Grade 7 Science. Cooper , Schindler and Sun contend that the analysis of integration factors enhances understanding of ICT integration phenomenon (Cooper, Schindler & Sun, 2006). Various researchers state clearly that “the set of interrelated concepts, definitions, and propositions that are used to explain and predict phenomena are called theories.” Kerlinger and Lee (2000) concede that theories explain phenomena through interrelatedness of variables, for example, from sources such as prior empirical research, past experiences and observations of actual behaviour, attitudes or other phenomena.

Sayer opines that “…the aim of theories is to order, explain and predict especially during data collection, analysis and testing of hypotheses” (Sayer, 2000). Theories also function to give rigour to a research (Cooper & Schindler, 2001, p. 51; Dollinger, 1999). In this research, theories are used to explain the different ICT integration factors. In this research, descriptive theories are used to explain the different ICT integration factors.

Descriptive theories are used to discuss causal powers of the ICT integration factors. The theories focus on aspects such as teacher pedagogical beliefs, barriers to integration, teacher skills (TPACK) and contexts.

2.3. ICT Integration

This section is aimed at demonstrating the significance of ICT integration practices in education sectors of several countries around the world, including South Africa, covering subjects of choice including Science mostly at K-12 classes and specifically Grade 7 or 8.

ICT in education has the potential for improving conventional teaching and learning (Baytak et al., 2011, p. 140). One cardinal property of educational technology is that ”…it makes learning more interesting, enjoyable and interactive. Kids today love learning by doing, discovering, and interacting” (Baytak et al., 2011, p. 140).

To level the playfield to the reader, it is important to crystallize the understanding of the integration of ICT in education, by defining the concept of 'ICT integration'. The concept of ICT integration assumes that the teacher and learner both have some understanding of how to operate the technology and that they are incorporating it into their teaching and learning activities. Despite Bebell, Russell, and O'Dwyer (2004) who argue that there is no clear standard definition of technology integration in K-12 schools, Table 1 below is an attempt by several researchers to define the concept 'ICT integration'.

Table 2. 1: ICT integration definitions

Two types of ICT use are discussed, namely, "learning *about* computers (or representational use) and learning *with* or *through* computers (or generative use)" (Hokanson & Hooper, 2000).
"Technology integration is meant to be cross-curricular rather than become a separate course or topic in itself" (Flanagan & Jacobsen, 2003).
ICT integration in education is understood or defined in terms of computers as tools in four phases, namely: "representational tools where ICTs are employed to merely reproduce information in another medium; as 'cognitive tools' where ICTs are harnessed to generate and develop ideas by individuals primarily; as 'meditational tools' where ICTs are engaged in supporting the co-construction of knowledge; and finally, as 'transformational tools' that start to challenge our current conceptions of teaching and learning and thereby help us to re-shape who we are by challenging what we do" (Hodgkinson-Williams, 2006).
"ICT integration does not simply refer to the placing of computers in the classroom; nor does it refer to the use of technology to support traditional teaching methods"(Smaldino et al., 2008) cited in (Du Plessis & Webb, 2012).
ICTs for learning: The learner uses ICT equipment as a tool or methodology for learning about a new idea or principle – e.g. this could include the learner doing research via internet search engines, doing calculations on creating graphs with specialised software or editing pictures taken by cameras or other images (Department of Basic Education, 2011).
"Integration implies that technology is used to facilitate teaching and learning, i.e. where students learn with or through ICTs" (Nkula & Krauss, 2014)

For the purpose of this study ICT integration will be defined as using technological resources such as smartboards, tablets, projectors, computers and relevant software in teaching and learning Science.

2.4. Science in Grade 7

This study was based in Grade Natural Sciences classes. For the purpose of this study Science was used for Natural Sciences. Natural Sciences is one of the Nine subjects according to National Curriculum Statement: Curriculum and Assessment Policy Statement Grades R-12 issued by the Department of Basic Education, which are done by all Grade 7 learners. 'Science is systematic way of looking for explanations and connecting the ideas we have, certain methods of enquiry and investigation are generally used' (Department of Basic Education, 2011). According to DBE, amongst the cognitive and process skills that learners will be able to develop in Natural Sciences, there is Scientific process which is 'the way of investigating things about the world, Scientists use this process to find out about the world and to solve problems (Department of Basic Education, 2011, p. 11).

Following from the foregoing assertions, the integration of ICT is not a panacea for all educational challenges, consequently, the literature review is reflecting challenges to ICT integration in science teaching and learning, among others, first-order and second-order barriers/issues. These barriers and factors that pose challenges to the integration of science technology are discussed in Section 2.6.

2.5. ICT Integration positive Impacts

If ICT in science is properly integrated during the conventional pedagogical practices as discussed above under section 1.4 in chapter 1, the benefits of the use of ICT in schools are immense compared to conventional teaching and learning in science (Bingimlas, 2009). Undoubtedly these effects would go a long way in uplifting the socio-economic realities of countries around the world and Africa including South Africa. Research work indicates importantly that learners' use of ICT simulations helped improve their understanding of science ideas significantly (Hogarth, Bennett, Lubben, Campbell, & Robinson, 2006).

Mdlongwa (2012) concedes that the benefits due to ICT integration among others are: Learners were producing knowledge themselves and through ICT learners were connected to experts and had access to the global world.

Another major benefit of using ICT in science education is that “it expands the pedagogical horizons and resources available to science teachers” (Al-Alwani, 2005). On the other hand, Sukhnandan, Lee and Kelleher (2000) opine that although ICT cannot replace classroom teaching entirely, it has the power “to increase deeper understanding of the principles and concepts of science as it could be used to provide new, authentic, interesting, motivating and successful educational activities” (Sukhnandan, Lee, & Kelleher, 2000)

According to Becta (2003); Bingimlas, (2009) and UNESCO (2010), there are five key success factors influencing the likelihood of a successful ICT integration in basic science:

1. “ICT resources;
2. ICT leadership;
3. ICT teaching;
4. School leadership”; and
5. “General teaching” (Bingimlas, 2009).

Tinio (2012) confirms the positive impacts of ICT in science. Even though there is evidence about the potential of technology-rich mathematical tasks to impact learners’ learning, not every teacher is using the technology in teaching and learning (Lawless & Pellegrino, 2007). For the purpose of this study, teaching and learning is based in Grade 7 Sciences classes.

2.6. ICT Challenges

As already alluded to at the end of Section 2.4, ICT opportunities or benefits and effective integration must be understood among challenges or weaknesses which cannot be entirely ignored if successful integration is to be guaranteed. Consequently, the prime purpose of this section is to highlight these challenges which are mostly experienced during integration. Numerous researchers have therefore conducted investigations on the significant role of the barriers to integration in science teaching

and learning (Al-Alwani, 2005; Bingimlas, 2009; Gomes, 2005; J. Osborne & Hennessy, 2003).

According to researchers these barriers/issues are categorized as first-order barriers/issues and second-order barriers/issues in order to enhance the understanding on the role of the challenges/barriers on the ICT integration (Almohaissin, 2006; Lewis, 2000; J. Osborne & Hennessy, 2003; Özden, 2007). The first–order or extrinsic barriers/issues are understood as equipment, environmental and community-related, whilst the second-order or intrinsic barriers/issues are school-level factors such as organizational culture; and teacher level factors.

In addition to the above barriers/issues some generic constraints are listed by Yonazi et al. (2012). These are cited by Yonazi as:

- Non-existence of guidelines and policies;
- No funding for equipment;
- Inappropriate content;
- Inaccurate, up- to- date data on education; and
- The tendency of ICT to accentuate social, cultural, and economic disparities" (Yonazi et al., 2012).

The above barriers can lead to failure for the proper implementation of ICT in teaching and learning. Educators must be supported enough technical to help them in using different ICT resources (SS Albugami & V Ahmed, 2015).

2.6.1. Some International examples

The integration of ICT in America is informed by lessons learned from experiences drawn from pilot studies conducted in fifteen countries in North America, Europe, Asia, and Latin America. The "ICT in Turkey schools" protocols were ratified by countries around the world for adoption and implementation in their countries as good practices. Countries that ratified the policies were Argentina, Australia, Canada, Chile, Hong Kong, Indonesia, Italy, Malaysia, Philippines, Singapore, South Korea, Thailand, the United States, Venezuela and South Africa. For Turkey, the implementation was a huge success, and these policies are now worldwide practices.

The “ICT in Turkey schools” protocol leads to successful implement during integration, because it takes into consideration some pitfalls globally such as barriers to integration, teacher’s pedagogical beliefs, teacher’s self-efficacies and knowledge areas for ICT. The note or protocol covers in detail other areas of concern needed to guarantee success in the integration of ICT in schools in all subjects including science.

These areas are:

- “Issues related to overall policy environment;
- Education Environment;
- Policy and Regulatory Environment;
- Policy at the school management level;
- Policy and Strategy to help Schools integrate ICT;
- Organization and Resource Management in Schools;
- Professional Development”; and
- “Curriculum and Content Development” according to Hogarth et al. (2006)

In America, a longitudinal research work is currently underway for finding ways and means in the use of ICT simulations in the teaching of sciences to enhance the higher thinking learning in classrooms (Hogarth et al., 2006). Preliminary studies are already indicating that students being taught using ICT simulations were more effective than those involved in non-ICT teaching activities for supporting science ideas. The African ICT Integration follows in Section 2.5.2 below.

Bingimlas (2009) emphasizes the importance of a properly integrated ICT and the role it plays towards student preparation for the 21st-century life. He furthermore asserts that in primary schools, technology can be utilized in primary science education resulting in numerous other educational improvements such as students collecting data on their mobile phones (m-learning), interacting with resources and conducting communication and collaboration, engendering student motivation, growing interpretation skills with data as well as expanding the pedagogic resources available to teachers.

As a sequel of the foregoing, during 2014 at the 6th international conference on Africa ICT, a consensus was reached citing Cameroon ICT integration as an example to be

followed, that is, for a successful integration of ICT in African schools for all subjects including science. In Cameroon a causal experimental pathway involving two variables, that is, independent and dependent variables were followed (Kituyi, 2014). This Cameroon case considered two variables which could be categorized as inputs and outputs for ICT integration process in schools. Specifically, these variable categories could be described as *independent/exogenous* and *dependent/endogenous* variables. The causal link between the independent and the dependent variables can be illustrated as in Figure 2.1.

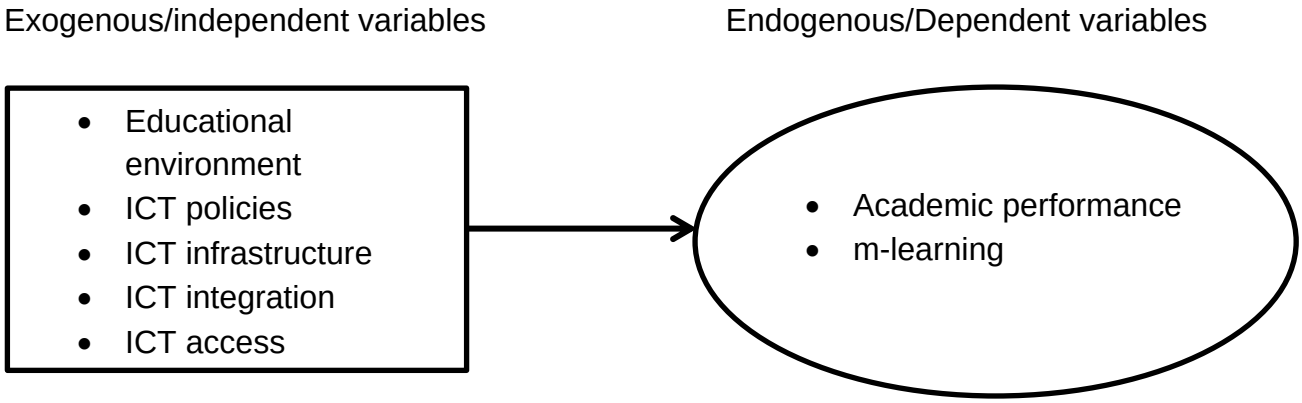


Figure 2. 1: Independent and dependent variables

Adapted from (Kituyi, 2014, p. 446)

Figure 2.1 indicates that if ICT has been properly integrated into education the prospects of a successful integration are greater, whilst allowing barriers, teachers' pedagogical beliefs, teachers' low efficacy and lack of ICT knowledge to influence the integration process could have dire consequences leading to unintended outcomes.

The foregoing causal links can also be represented mathematically as follows:

K=f[x1+x2+x3+x4+x5+x6]

Where K =performance as the outcomes; and

x1=Educational environment

x2=ICT policies

x3=ICT infrastructure

x4=ICT integration

x5=ICT access

x6=Cultural awareness

This equation implies that for a successful integration the independent variables should be optimized. A discussion of the South African integration follows in the next section.

2.6.2. South Africa

Despite the adoption of the “ICT in Turkey schools” protocol as in Section 2.5.1 above, there is still slow growth in the integration of ICT in South Africa. Draper (2008) argues that “South Africa faces considerable challenges in education as a whole and more especially with the implementation of ICT in science classrooms”. Mathipa and Mukhari (2014) confirm that South Africa is confronted with, among others, barriers to integration such as internal barriers, external barriers or factors influencing the use of ICT. The teacher barriers met by teachers on different levels are:

- Internal barriers
  - “Lack of confidence;
  - Lack of competence for ICT integration” (Bingimlas, 2009; Tedla, 2012)
  - Resistance to change pedagogical beliefs (Makgatho, 2012)
- External barriers
  - “Lack of access to ICT resources” (Eze & Olusola, 2013)
  - “Lack of time for ICT” (Sicilia, 2005)
  - “Lack of effective training” (Tedla, 2012)

Above barriers need to be attended to by the leadership of the school for better ICT integration.

2.6.2.1. Teacher professional development

Regarding a strategy for teacher professional development (TPD), the continued development is a requirement. This does not only refer to subject knowledge but is also required to ensure mature attitudes, the correct skills and both technical and pedagogical knowledge for in-service teachers as well as pre-service teachers. The correct background obtained through professional development is a prerequisite for the successful integration of technology in the classroom activities. In this regard literacy technology programmes and context technology literacy programmes are critical. Scaffolded Teacher Professional Development programmes should therefore

be made available to help teachers structure the use and development of cognitive ICT tools. An appropriate technology integration framework should include technology skill development and pedagogical use of technology.

Researchers are finding that lack of interest and motivation in science subjects is partly responsible for the high science failure rate (Learningenglish, 2016; Motshekga, 2016). The following are Grade 12 results of mathematics and physical science from 2016 to 2017.

Subject	Number wrote 2016	Number passed 2016	Number wrote 2017	Number passed 2017	Change (passed)
Mathematics	265 810	135 958	245 103	127 197	-8 761
Physical Science	192 618	119 427	179 561	116 862	-2 565
Guaranteed Engineering entry	**Number above requirements 2016**	**% of total 2016**	**Number above requirements 2017**	**% of total 2017**	**Change**
Mathematics (80%)	7 974	3.0%	6 726	2.7%	-1 248
Physical Science (70%)	17 143	8.9%	16 531	9.2%	-612
Guaranteed Computer Science entry	**Number above requirements 2016**	**% of total 2016**	**Number above requirements 2017**	**% of total 2017**	**Change**
Mathematics (70%)	18 075	6.8%	16 565	6.8%	-1 510

Figure 2. 2: Results of Mathematics and Physical Science from 2016 to 2017

Source: Sloane, H. (2018)

Figure 2.2 illustrates the results of learners who wrote mathematics and physical science, the number of learners gaining guaranteed engineering entry and guaranteed computer science entry as well as the number of learners who wrote versus learners who passed from 2016 to 2017. While 51.9% and 65.2% of matric learners passed maths and science, respectively, even fewer passed with high enough marks to enter the engineering or computer science fields.

The figure gives the number of learners who wrote versus learners who passed. In all three categories almost halve of the learners who wrote failed. The innovation of technology is anticipated to reduce the high learners' failure rate by increasing the

deeper understanding of abstract concepts in science (Draper, 2010; M.M.M Kazeni, 2012; Polly et al., 2009; William & Kyle, 2006).

There might be many factors, but it gives rise to a concern to do a study like this to try and do research on what the challenges or benefits are for teachers and learners in ICT integration in Science as early as in primary school.

2.6.2.2. ICT4RED project

In a bid to address the quality of education in rural areas the South African Department of Science and Technology (DST) in collaboration with the South African Department of Basic Education (DBE), the Eastern Cape Department of Education (ECDoE), and the South African Department of Rural Development and Land Reform (DRDLR) in 2013 initiated the ICT for Rural Education Development (ICT4RED). The ICT4RED was aimed at exploring how the deployment of new and existing technologies at schools in Cofimvaba town in the Eastern Cape Province could contribute to the creation of a model that could be duplicated and deployed to other parts of the country, including the rural education systems. (Botha et al., 2013). ICT4RED supports the integration of tablets in teaching by rural teachers with the aim of assisting in alleviating the problems of quality education in rural areas as described by the current research. There were twenty-five schools in the pilot project.

Important aspects to be considered by future research based on ICT4RED project are the following:

- Leadership is an important parameter during ICT integration;
- Ownership and buy-in from staff members, parents, and SGB are paramount;
- Teachers should be held accountable;
- Teacher and parent relationships are vital for successful integration;
- Technical support is essential;
- Control over tablets used by students is essential;
- Infrastructural issues need immediate attention;
- Teacher pedagogical beliefs play a role in successful ICT integration;
- Barriers/challenges to integration need to be considered;
- Teacher skills (TPACK) are essential; and

- The context and environment for implementation are important.

Despite policy enforcement by the government of South Africa, there is still minimal progress in the adoption and integration of ICT in South African schools (Ndlovu & Lawrence, 2012).

2.7. Critical realism as an approach

A social research work of this nature, that is, of the integration of ICT in teaching and learning of science, would not be complete without taking some consideration of the perception-based models rooted in critical realism. Until now, the different conceptual frameworks discussed in Section 2.7 below, have not considered the relative freedom that the teachers and learners have to address certain ICT integration principles, adherence rules and integration guidelines based on their personal values (Cox, Preston, & Cox, 1999; Nemaenzhe, 2010; Wong, Divaharan, Liu, Peer, & Williams, 2006). This is a central reality that merits further attention (Van der Merwe & de Swardt, 2008).

This research emphasizes that the success or failure of ICT integration in schools by teachers/learners/ICT technicians rest more directly on their own choices/decisions or value judgment. For example, teachers' and learners' attitudes and other second-order barriers towards ICT integration can result in unintended or intended integration outcomes and lead to successful or unsuccessful ICT integration (Parsa, Self, Njite, & King, 2005). The stance of Parsa is affirmed by several researchers (De Tienne, Shepherd, & De Castro, 2008; Ekanem, 2010; Hayward, Shepherd, & Griffith, 2006; McKelvie, Haynie, & Gustavsson, 2009). Muianga et al., (2013) without considering the perceptions or value judgment of stakeholders have re-affirmed factors that are responsible for a successful or ineffective integration as previously researched (Nachmias, Miodusar, Cohen, & Forkosh-Baruch, 2004).

Different researchers have emphasized the meanings/choices or value judgement-located theories based on the critical realist approach (Carter & Van Auken, 2006; Danermark et al., 2006; Fleetwood & Ackroyd, 2004; Michael & Combs, 2008; Perry, 2002).

The foregoing researchers maintain that for the intended and unintended integration outcomes, the teacher should be allowed to give an account of their concrete actions regarding their pedagogical beliefs or second order barriers. This must involve the researcher interviewing the teachers and other stakeholders to get first-hand indications of the nature and outcomes of the power play between success and failure to understand the deeper reasons underlying the successful and unsuccessful ICT integrations in teaching and learning of science in Grade 7 (Danermark et al., 2006).

The critical realist approach to ICT integration reveals that the reasons or challenges for unsuccessful/unintended outcomes in the ICT integration of science by teachers or other stakeholders, need to be classified into categories for future consideration to enhance the understanding of the multiplicity of causal factors needed to be absented for successful ICT integration in other outstanding subjects (Bhaskar, 2000). Understanding such perceptions, it is argued, provides salient information for teachers and other stakeholders they may be ignorant of so that solutions to integration challenges can be found. As discussed in the critical realist method used as supporting the approach of this research the real level is represented by the ICT integration policies and guidelines as well as the challenges/factors driving successful or unsuccessful integration. The actual level providing insights in integration is represented by the teachers, learners, parents and the local contexts in which the integration is taking place.

These two elements of the critical realist philosophical approach provide the basic explanation for the success or failure in the ICT integration. The research approach explains more regarding the applicability of critical realism as a philosophical method for the integration of ICTs in education (Colier, 1994). Its superior utility is that unlike positivism, it reminds us that the everyday life, especially for teachers, learners and their social reality does not operate in isolation like a controlled scientific experiment but is always an open system where stakeholders can express their opinions regarding the challenges of integration at hand. Figure 2.3 illustrates the levels of ICT integration in education.

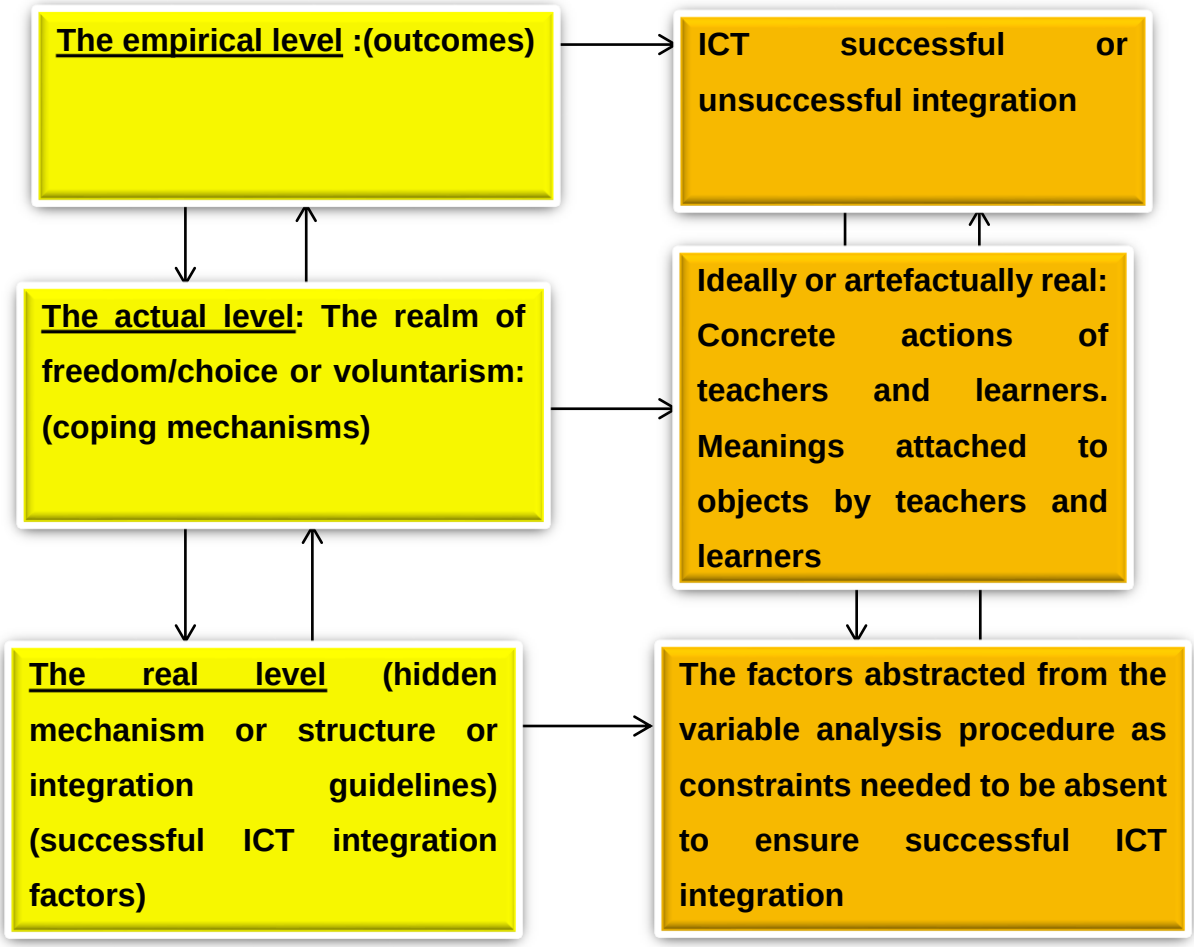


Figure 2. 3: Levels of the ICT integration in education

Source: Based on Fleetwood & Ackroyd (2004:152); Jeppesen (2005:1) and Danermark et al., (2006)

Figure 2.3 focuses on the activities of the teacher, learner and ICT technicians in ICT integration by concentrating on the aspects or factors that need to be considered when integrating ICTs. According to Fleetwood and Ackroyd (2004), these factors are:

- The importance of having skills to integrate;
- Dealing with the first order and second order barriers;
- Aligning teacher pedagogical beliefs with practice to ensure integration;
- The importance of considering the context and environments when introducing and integrating ICTs. Also included are:
- The teachers/leaners coping mechanism and.
- Teacher voluntarism or freedom to integrate or not.

The ICT integration factors together with the integration guidelines, rules and policies occupy the real level in Figure 2.3. This model represents the three-tiered ontology comprising of the real, actual and the empirical levels as discussed below. The social reality is comprised of ideally real, material reality, artefactual real, and social realities. This research falls under the artefactual and social real aspects of ontology. The critical realist work predisposes the relationships between what (what one experiences or observes empirically), how (what happens) and why (underlying mechanisms).

A concise description of the levels in figure 2.3 above follows from bottom-up is according to Fleetwood & Ackroyd (2004:152); Jeppesen (2005:1) and Danermark et al., (2006)

Real level

It represents the mechanisms responsible for the successful/unsuccessful ICT integration comprising of the factors for integration, rules, policies, and contexts. This social real level is both constraining and enabling in the sense that the different stakeholders can interpret the outcomes differently.

Actual level

It is the domain where events take place. Teachers and learners can explain the meaning of mechanisms at the real level in different ways to produce either intended or unintended outcomes. This level represents the location of the freedom or agency where the teacher/learner/technician can take definite actions to integrate or not. The teachers who are instructivists will be predisposed to unintended or unsuccessful ICT integration outcomes, whilst the teachers who are constructivists will experience intended or successful integration outcomes. Such teacher instructivists would reify the barriers seeing them as immutable. But teachers who are constructivists have a strong tendency towards successful ICT integration.

Some of the salient features of the critical realism are that through critical realism transformations instructivist teachers can be helped to evolve from their traditional pedagogical beliefs. These transformations can be used to overhaul the nature of processes within the real level, for example, policies, rules and guidelines for ICT integration in schools.

Empirical level

It represents the outcomes and, in this instance, the observable unintended or intended ICT integration. These outcomes stem from the interactions between the real and the actual levels. This indicates that to understand successful (intended) or unsuccessful (unintended) ICT integration one needs to question the real and actual levels. The above model suggests that to understand the nature of outcomes or their causality one needs to look at both the real and actual levels.

2.8. ICT integration frameworks

Technology integration practices are many and varied. Most researchers have used conceptual frameworks to inform ICT integration in education. The central theme threading through all of them though is that the teacher is still at the center of integration, but only the teachers' pedagogical beliefs have evolved from being teacher-centric (instructivist) to being learner centric (constructivist teaching practices) allowing teachers to become facilitators within the classroom.

ICT integration in the teaching and learning of science can be understood in terms of five discernibly different conceptual framework themes/practices, which have been extracted from case studies and categorized as themes/practices in this research. Theme/practice 5 which is a modified TPACK integration framework is discussed, under Section 2.8.1. Emerging from the literature review four other ICT conceptual frameworks have been identified for this study as discussed below.

2.8.1. THEME/PRACTICE 1:

The transformational ICT integration framework

Balanskat, Blamire and Kefala (2006) claim that "…there are three levels of integrating ICTs, into learning, namely, functional practice, integrative practice, and transformational practice" (Balanskat, Blamire & Kefala, 2006). These levels are explained as below.

2.8.1.1. Functional practice

It is explained as the lowest and simplest entry level where learners make use of the computer in simple functional ways for activities that computers can do well – such as calculations using spreadsheets, word processing, data manipulation and presentation, producing graphs, manipulating images and searching information on the Internet. This level largely has to do with the learning of computer skills and usage. Teachers might ask learners working at this level to type up a report on a project that include information found on the internet and a budget that utilised spread sheets. This model basically uses the computer as a tool to accomplish tasks that would previously have been accomplished in other ways more efficiently.

2.8.1.2. Integrative practice

This second level is understood simply as when learners use programs to engage in more sophisticated activities, for example drafting and re-drafting a piece of writing. The teacher begins integrating her teaching goals with the activities of the computer, and consequently, new pedagogical ways emerge, such as facilitation, editing and revision, and learners improve from once-off activities to methods of drafting and redrafting which were not practiced before. Learners writing by so doing are changed from the conventional ways to ICT integrated writing (Balanskat, Blamire & Kefala, 2006).

2.8.1.3. Transformational practice

According to the third and final level of integration, is understood and characterized by learning which occurs as a result of activities and opportunities which do not exist in a computer-less environment, for example, collaborative online projects and synchronous chats. Learners are engaged as knowers (Barnett, 2004 p. 248) so that classroom activities become transformational.

2.8.2. THEME/PRACTICE 2:

The integration of ICT as ‘tools’

According to (Hodgkinson-Williams, 2006) ICTs are being integrated into a four-stage ‘tools’ conceptual framework. The framework stipulates that there are four discernible

different stages of computer use as ‘tools’ that are necessary for the integration of ICT during teaching and learning. The four stages follow:
First stage: As ‘representational tools’ where ICTs are used to reproduce information in another medium;

Second stage: As ‘cognitive tool’ where ICTs generate and develop ideas by individuals;

Third stage: As ‘mediational tools’ where ICTs support the construction of knowledge. Mediation tools typically are, for example, e-mail, computer conferencing, discussion lists, bulletin boards and internet relay charts); and

Fourth stage: As ‘transformational tools’ that start to challenge current teaching and learning concepts as well as improving everyday teaching and learning.

2.8.3. THEME/PRACTICE 3:

The Intel® teach essentials course as an ICT integration framework
Light, (2009) points out the four dimensions used to integrate ICT in India, Turkey, and Chile. These dimensions are set out below.

2.8.3.1. Changes in teachers’ knowledge, believes and attitudes

When ICT is integrated into developing countries the following themes resulted:

Teachers’ beliefs moved towards a constructivist view of teaching and learning;
Teachers understood student-centered practices better; and
In the process, teachers experienced the benefit of improving their ICT knowledge.

2.8.3.2. Changes in how learners engage with content

When ICT is introduced in schools, learners improved the way they interacted with content in several ways:

Projects utilising ICTs gave learners the opportunity to work collaboratively, use multiple resources and take responsibility for their own learning;

Independent internet research gave students the freedom to develop and share their own perspectives;
School content became a more integrated part of students' lives, making learning more meaningful to students.

2.8.3.3. Changes in relationships among teachers, learners, and parents

Teachers, students and parents reported improvements in all the manifestations of their relationships including the wider community, as follows:

ICT activities in support of projects promote collaborative relationships among learners;
In addition, the new teaching strategies made possible by ICT integration promoted collaborative and interactive relationships between teachers and students;
Lastly, the effect of the new ICT based projects strengthened the relationships between the school, parents and the community.

2.8.3.4. Changes in the use of ict tools to promote students' learning

When ICT is properly used as a learning aid effective and sustainable educational reform was experienced.

2.8.4. THEME/PRACTICE 4

The TPACK ICT integration framework

TPACK is the chosen applicable general conceptual framework chosen for the study, to structure the thinking about "what knowledge teachers must have to integrate technology into teaching and how they should develop this knowledge" (Schmidt et al., 2014, p. 123). For this study, the conceptual framework was based on the technological knowledge (TK) of the teachers who were involved in the study, their pedagogical knowledge (PK) and content knowledge (CK). The content knowledge (CK) in the recent curriculum is standardized, teachers are teaching according to the policy documents of different subjects. The study was on the content knowledge that was presented during the observation, not on general teachers' content knowledge of Science as the subject. According to Mishra and Koehler (2009) for a successful ICT

integration, teachers who remain at the centre of integration still need several prerequisite skills. TPACK was very important in this study.

According to TPACK the effective integration of new technologies like ICT in education, especially science education, requires teachers to possess an optimal understanding in the interacting relationship between the components of knowledge, namely: Pedagogy, Content, and Technology (Shulman, 1986). For the effective integration of ICT in the curriculum to support and influence teaching and learning, teachers must possess the seven basic knowledge and practices which are:

"PK-Pedagogical Knowledge;
TK-Technological Knowledge;
CK-Content Knowledge;
TPK-Technological Pedagogical Knowledge;
TCK- Technological Content Knowledge;" and
"TPCK-Technological Pedagogical Content Knowledge" (Mishra & Koehler, 2006)

A review of the literature suggests that "…science teaching, worldwide, lacks explicit connections of science content with learners ; day-to-day experiences" (William & Kyle, 2006).

According to Gorder, "Effective integration of technology is the result of many factors, but the most important factor is the teachers' competence and ability to shape instructional technology activities to meet students' needs" (Gorder, 2008). Teachers can play an important role in the integration of technology in teaching to support learning. According to Baylor and Ritchie, "schools that are successful in integrating technology into the curriculum are often guided by a comprehensive technology use plan or principles underpinned, among others, by key success-factors" (Baylor & Ritchie, 2002, p. 396).

Technology can benefit learners' learning "when teachers use it effectively in the classroom" (Gülbahar, 2007; Kim & Hannafin, 2011). The foregoing researchers believe that teachers are managers of their classrooms and they can support learning through different pedagogical practices. According to Ayas, "emerging educational technologies, especially computer and the Internet technologies, have indeed become powerful tools in the classroom as they influence teaching and learning today" (Ayas,

2006, p. 14). Technology can take on multiple roles in education, including the role of resources, the role of the delivery system, or that of productivity tool. (Baytak et al., 2011; Lee1, Waxman2, Wu1, Michko3, & Lin, 2013).

For completeness in the effective integration of ICT there is a need for consideration of quality school leadership; cooperation and coordination among all stakeholders; creating innovation culture; and learning from others (Hwang, 2011). In summary, when the educational system (Department of Education) is faced with the need to transform education, the most effective ICT integration process to follow is through mandating policies to change different curricula involving pedagogy and content. The educational system then affects the overhauling by providing ICT resources and infrastructure to schools. The schools, in turn, provide the ICT resources (hardware; software) to the learning environment (teachers; learners; technicians; learning community). The overhauled learning environment experiences changes in the school culture (attitudes; beliefs) because of ICT training of teachers and learners. The training imparts ICT resource capabilities to teachers and learners for effective implementation of ICT (S. Albugami & V. Ahmed, 2015; Newhouse, 2002).

The necessary teacher knowledge skills to be considered that are needed for an effective ICT integration are:

Technological Knowledge (TK) about the different technologies, as well as according to Koehler and Mishra “Content Knowledge (CK) about the subject being taught;

Pedagogical Knowledge (PK) about teaching methodologies;
Technological Content Knowledge (TCK);
Technological Pedagogical Knowledge (TPK);
Technological Pedagogical Content Knowledge (TPCK)” (Koehler & Mishra, 2009).
The implementing teacher now endowed with the above skills can overcome his pedagogical belief system, encouraged to move from being an instructionist, where traditional teaching methodologies remain dominating and move towards being a constructionist, where he is motivated to integrate the ICT in the curriculum. The following is the modified TPACK.

2.8.5. THEME/PRACTICE 5

The modified TPACK integration framework

Having critically reviewed the above TPACK integration model, Nkula and Krauss (2014) agree with Graham (2009) who opines that the TPACK model has weaknesses that were inherited from the original Pedagogical Content Knowledge (PCK) model by Shulman (1987), which lacked theoretical clarity. For example, TPACK does not consider matters beyond content, pedagogy and technology such as beliefs and context. It comprises, among others, of categories that do not have exact definitions, that is, TCK has thirteen definitions, TPK has ten definitions and TPACK has eighty-nine definitions. The researchers concluded that the TPACK model is oversimplified. Consequently, there is a modified version. The modified TPACK version suggests that the teacher's skills and knowledge as before are still necessary during ICT integration. The new version maintains that teacher's belief system plays a role in the implementation of ICT, for example, teachers with traditional pedagogical beliefs will mostly use ICT in a representational way, which is, instructing the learners like before. Whilst teachers with constructionist beliefs will use ICT in a generative fashion where the teaching is learner-centred. The new framework considers a lot more aspects of the integration aspects and guidelines such as teacher knowledge and effective integration, teacher's pedagogical beliefs, and first order and second order barriers. The framework creates an alignment between the foregoing different skills categories and their contexts for an effective integration, that is, teacher's beliefs are aligned and issues on the first order and second order barriers are resolved (Nkula & Krauss, 2014). The following is conceptual framework of the study.

2.9. Conceptual framework

The researcher used TPACK as a conceptual framework. The conceptual framework was discussed above.

In this section, the researcher turns to the concept of a conceptual framework for the study. The conceptual framework was primarily used as a lens for a deeper understanding of the complex and challenging theory of ICT integration in education, specifically for Science. Existing literature illuminates that despite various means to

motivate students for science, trends across developed and developing countries show a drop in interest and take-up of Science, Technology, Engineering and Mathematics (STEM) subjects (Draper, 2010).

The input is necessary for addressing the problem statement and objectives for this study and for guiding data collection in the sections that follow. The conceptualization is therefore aimed at clarification and analysis of the key concepts in the study as well as to the way this research is integrated into the body of existing theory and research of the integration of ICT in science education (Draper, 2010; Mouton, 2002; Osborne & Hennessy, 2003).

The field of ICT in education is anchored in theories of pedagogy content knowledge (PCK) as per Shulman (1987) in Figure 2.5 more recent technology integrated pedagogy (TPCK) as per Mishra and Koehler, (2006) in Figure 2.6 modified technological pedagogy (TPCK) in Figure 2.7 The Four in Balance Model and the Adapted Four in Balance Model in Figure 2.8.

We now return to answer the overall problem statement of this research which states: What are the experiences of teachers and learners in Grade 7 Science in township schools in the Paperless project?

This section briefly explicates those artefactually and socially real entities with causal powers that enable and/or constrain the successful integration of ICT in Grade 7 natural science teaching, under the following epistemic and theoretical headings:

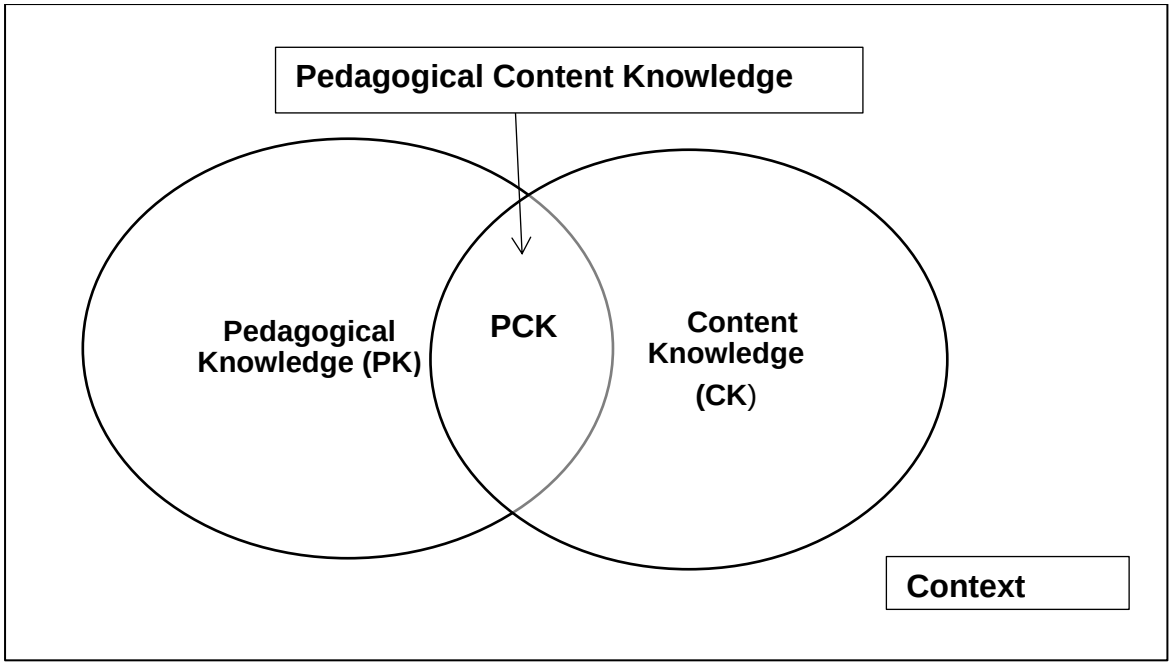


Figure 2. 4: Pedagogical Content Knowledge (PCK)

Source: Shulman, 1986 p. 8

The framework in Figure 2.4 briefly illustrates the need for merging Content Knowledge (CK) and Pedagogical Knowledge (PK) resulting in the Pedagogical Content Knowledge (PCK) needed for effective integration of ICT in education. Content knowledge (CK) is understood as the subject knowledge needed by teachers before they choose which correct technology to implement. Pedagogical Knowledge (PK) is understood as the teaching knowledge, that is, didactic versus technological teaching. This knowledge helps teachers to understand what learners' ICT needs are. This presupposes that teachers play a role in the choice of which technology to implement for their learners, that is, the teacher is still central to the ICT integration. Consequently, the teacher's level factors need to be considered before integrating ICT. Such factors to be considered before integration include barriers for integration such as teacher self-efficacy, ICT infrastructure, a science curriculum overloaded with content, teacher attitude, teacher's pedagogical beliefs and perceptions (Mishra & Koehler, 2006; Nkula & Krauss, 2014; Shulman, 1986).

Shulman (1986) largely omitted discussions on technology and how it related to Pedagogy, Content Knowledge and PCK. Angeli and Valanides (2009) consented to the omission. As a sequel of the omission of the technological integration by Schulman

in his 1986 PCK framework, subsequent researchers were obligated to develop his framework further into a Technological Pedagogical Content Knowledge (TPACK) framework that now includes the necessary technology for integration into education (Mishra & Koehler, 2006). The newly developed framework follows hereinbelow in Figure 2.5.

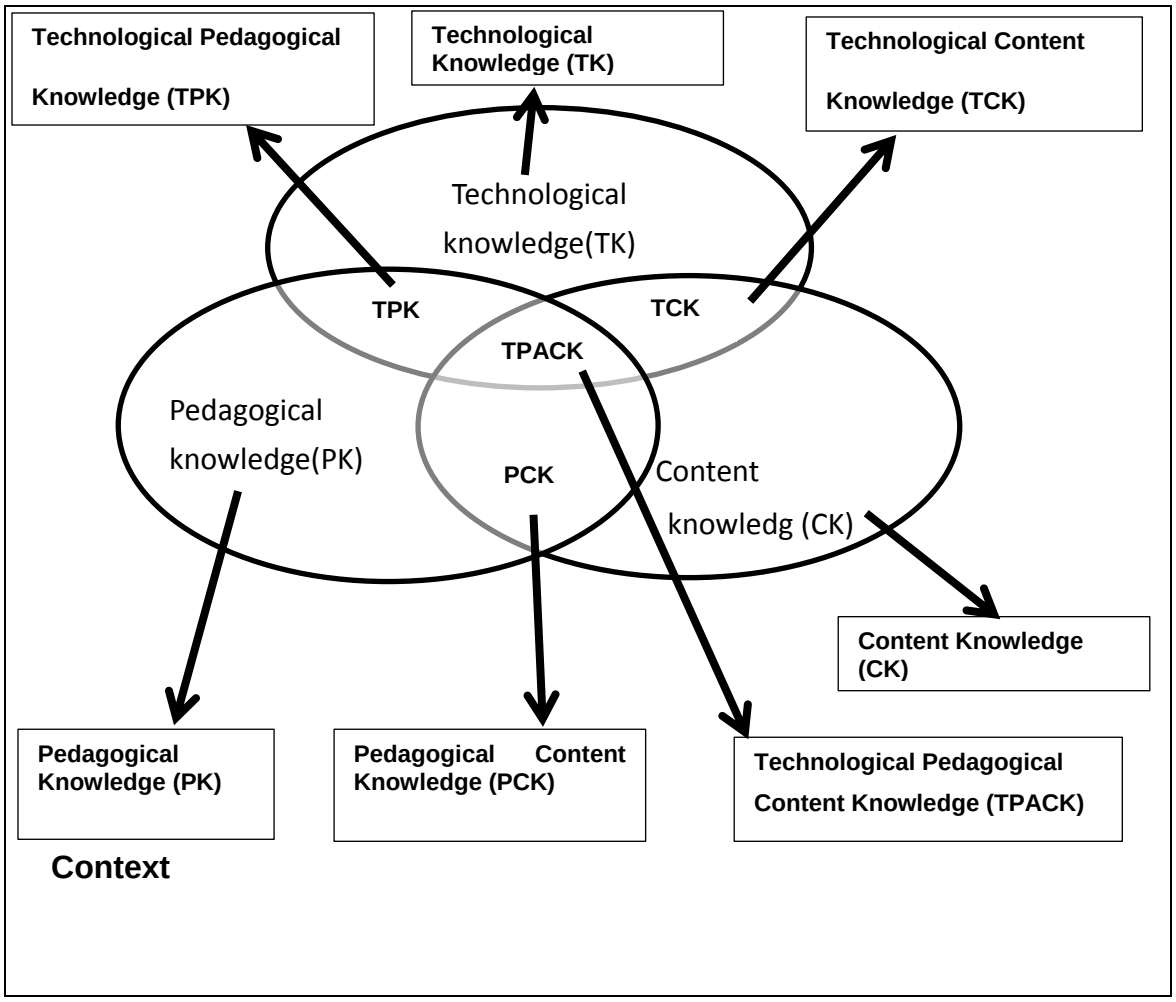


Figure 2. 5: TPACK as a framework for ICT integration

Source: Mishra & Koehler (2006)

Figure 2.5 is a TPACK framework developed from Schulman's (1986) conceptual model by Mishra and Koehler (2006). TPACK stands for "Technological Pedagogical Content Knowledge. It is a structure followed to comprehend and describe the content knowledge that is needed by a teacher for the integration of technology into the classroom." (Mishra & Koehler, 2006 p. 1025). It comprises of seven components which are:

Content Knowledge(CK), Pedagogical Knowledge(PK), Technological Knowledge(TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK). (Mishra & Koehler, 2006)

Content Knowledge (CK)-Content Knowledge is the teacher's knowledge about the subject being taught being considered for ICT integration.

Pedagogical Knowledge (PK)-Pedagogical Knowledge is the knowledge of teaching methods, processes, and practices. Teachers should be able to execute administrative duties such as students' methods of learning, classroom management skills, and pedagogical planning and student assessment skills.

Technological Knowledge (TK)-Technological Knowledge is the understanding of the different ways of thinking or various kinds of technologies and working different technology resources in the classroom, that is, from low to high technologies.

Pedagogical Content Knowledge (PCK)-Pedagogical Content Knowledge covers the main ideas for learning, teaching, and curricula.

Technological Content Knowledge (TCK)-Technological Content Knowledge is the comprehension of how technology and content influence one another.

Technological Pedagogical Knowledge (TPK)-Technological Pedagogical Knowledge is the understanding that learning and teaching can and will change when new technology is introduced into the classroom.

Technological Pedagogical Content Knowledge (TPACK)-Technological Pedagogical Content Knowledge is the foundation of effectiveness for teaching with technology.

According to Nkula and Krauss (2014 p. 249) TPACK's hallmark is to provide teachers with the pedagogical and technological practical skills necessary for the integration in the classroom. According to (Mndzebele, 2013) a lack of such knowledge and skills was an underlying factor for constrained ICT implementation in Swaziland. The value of implemented ICT in the classroom has been researched in the Netherlands culminating in the Four in Balance model presented below.

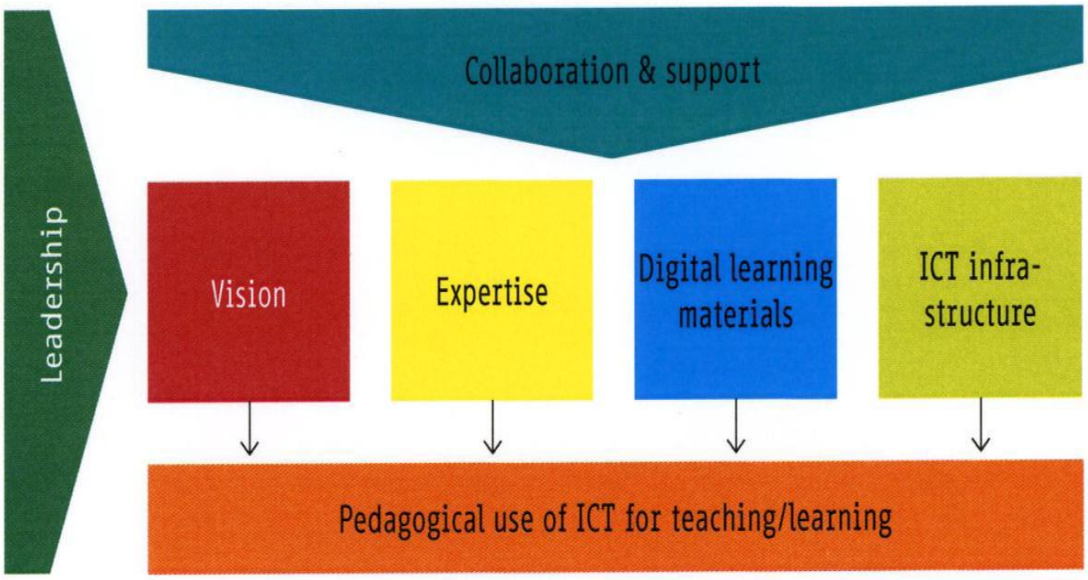


Figure 2. 6: The Four in Balance Model

Source: Basic Elements of the Four in Balance Model (Kennisnet, 2009, p. 13)

Figure 2.6 indicates that for ICT to show support to science learning in the Netherlands, leadership consisting of principals and schools' heads played a role in the collaboration and support of the ICT integration process by promoting the school vision (guidelines and policies) directing the implementation. They ensured availability of ICT infrastructure (computers) as well as digital learning materials (digital materials). When the four elements were in balance/symmetry ICT integration was found to be yielding value or support to the teaching and learning of science in education. From the Four in Balance Model another figure was adapted to highlight the factors needed for effective integration of ICT in education proposed for South Africa (Draper, 2010).

The following figure 2.7 was adapted from Four in Balance model for ICT supporting science teaching and learning in South Africa.

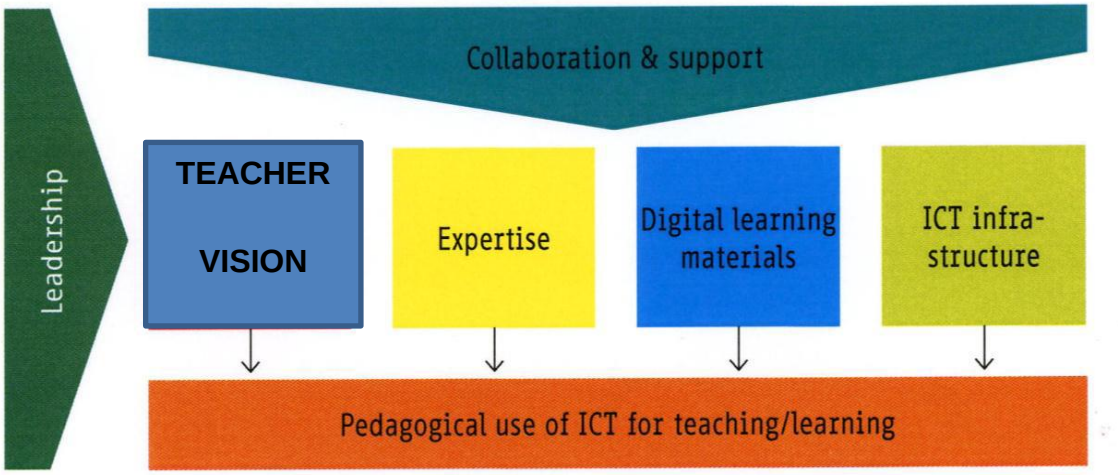


Figure 2. 7: The adapted Four in Balance Model

Source: Draper (2010, p.87)

Figure 2.8 summarizes the factors needed for effective integration of ICT in education proposed for South Africa (Draper, 2010). The model asserts that leadership should guide the implementation of effective policies. The leadership should allow for an environment conducive to learners and educators successfully integrating the ICT. The teacher who is at the centre of the integration is best suited to express his vision and expertise for the science subjects to be integrated, for example choosing, among other things, simulations and data-loggers. The teacher should be allowed to use his vision for the integration instead of the leadership vision. This then shows the value of integrating the ICT in the science education, that is, whether the ICT is supporting science learning.

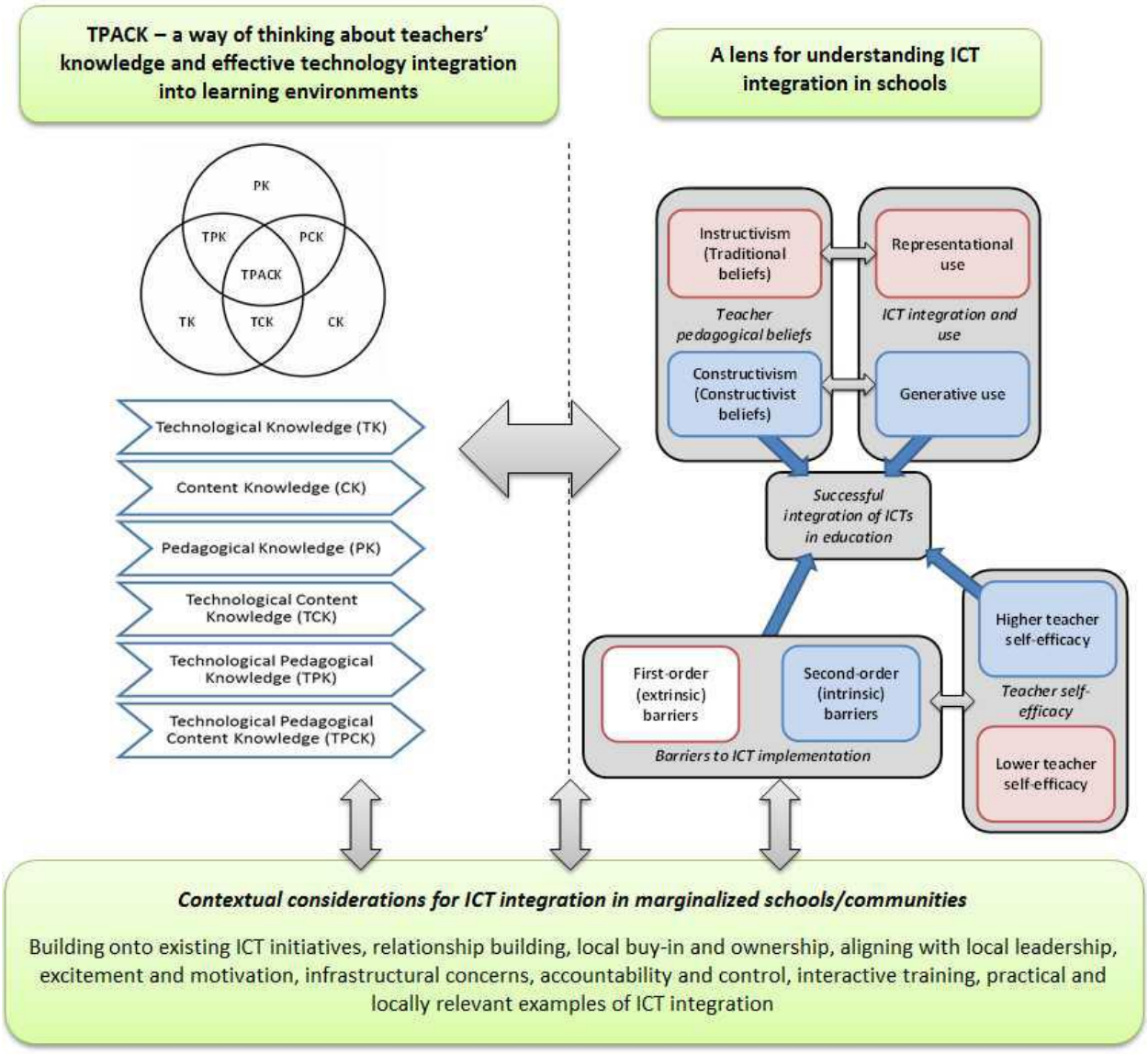


Figure 2. 8: ICT Integration in Education in Developing Contexts

Source: (Nkula & Krauss, 2014, p. 251).

Figure 2.8 illustrates that the TPACK model embedded in the figure and as established by Mishra and Koehler (2006) necessitated further refinements through research developments as it had inherent weaknesses (Nkula & Krauss, 2014). It had no theoretical developmental basis (Graham, 2009), had a high degree of parsimony and consisted of numerous different categories that do not have precise definitions (Nkula & Krauss, 2014).

As a sequel to the foregoing TPACK weaknesses, a newly adapted TPACK was introduced (Nkula & Krauss, 2014). Figure 2.8 as a refinement of the TPACK indicates

that the teacher is still at the centre of the integration process. The teacher is still faced with barriers during the implementation phase such as internal barriers and external barriers. For an effective ICT integration, the teacher needs to consider all foregoing factors as well as the environment/context in which the integration takes place. Successful integration can be achieved provided the teacher is aware of the factors such as barriers to integration, teacher self-efficacy, ICT integration and use, teacher pedagogical beliefs and environment or context. If the foregoing precautionary measures are taken, a successful ICT integration can be realized (Nkula & Krauss, 2014).

2.10.Conclusion

The American ICT integration practices under sub-section 2.6.1 are evident in the use of ICT rivals' practices in other countries such as in Africa and South Africa. Their approach eliminates predisposed and potential pitfalls, hence guaranteeing success. The African case indicates that independent variables need to be ameliorated for a successful ICT integration. A study needs to be conducted for the South African case aimed at benchmarking the use of ICT in schools for Science students incorporating American practices based on the use of simulations. The South African government should increase investment for ICT infrastructure. Learners need to be more involved in the use of computers, tablets, and ipads. Teachers should make more use of ICT tools. More studies need to be conducted regarding the perceptions of teachers, learners and ICT technicians in the sense of ICT integration in teaching and learning. The conceptual framework for this research was TPACK. Methodology for this research is outlined in Chapter 3.

Chapter 3

- 3.1 Introduction
- 3.2 Research question
  - 3.2.1 Primary question
  - 3.2.2 Secondary questions
- 3.3 Methodology
- 3.4 Conceptual framework
- 3.5 Data collection process
- 3.6 Data collection instruments
- 3.7 Data analysis
- 3.8 Ethical considerations
- 3.9 Conclusion

3. Methodology

3.1. Introduction

The study was based on information from two schools, referred to as school A and B. The researcher undertook the study on the technological knowledge and implementation in Science in Grade 7. Data collection instruments that were used were interviews, observations and questionnaires. Questions were based on interviewing the teachers regarding how they teach Science in Grade 7 through integrating ICT. In both schools, the study was about which technologies of teaching were used. This research was based on the indicators as discussed above. The researcher asked questions to the teachers concerning the way in which they were teaching with ICT integration. On Content knowledge (CK), the study was about how the subject content could be supported by ICT.

The issues to be addressed in this study was based on the following study objectives discussed earlier; these are:

- The performance or impacts of and the attitudes of the educators and the students in the schools towards teaching with ICT in the Science;
- The challenges being encountered by teachers and learners as ICT was integrated into the learning and teaching of Science in the schools concerned.
- The recommendations that could be made to improve the use of ICT integration in the teaching and learning of natural science in the schools.

Six themes were used to assess the impacts of ICT. The six themes were:-Technology (technological resources that were used by the school); Pedagogical (methods of teaching that was used by teachers when teaching Science); Content (content that was taught during the research); Pedagogical content; Technological content and Technological pedagogical content. See Section 2.8 on the conceptual framework.

3.2. Research Question

3.2.1. Primary question

What are the experiences of teachers and learners in Grade 7 Science in township schools in the Paperless project?

3.2.2. Secondary questions

1. How is ICT integrated into the Grade 7 Science classroom in the Paperless classroom project?
2. Which challenges did the participants experience during implementation?
3. How did the implementation benefit the teaching and learning processes?

3.3. Research Methodology

Research methodology is the strategy of “how to proceed in defining the nature of the relationship between variables” (Maree, 201, p.293). It describes the strategy for conducting the study, from when, from whom and how data was collected (McMillan & Schumacher, 2010).

The research process for this study was guided by the research onion of Saunders and Thornhill. The research onion was developed by Saunders et al. (2007) “to describe the stages through which the researcher must pass when formulating an effective methodology” (Essay, 2013, p.1).

The authors looked at the whole research process and they found the onion figure to represent the research process. The author explained the research process and gave it some order (Saunders et al., 2007). According to Saunders “The strategy is most often used in explanatory and exploratory research and can be a worthwhile way of exploring existing theory” (Saunders et al., 2007). The following figure is the research onion. The authors designed the research onion to guide the design of the research from the abstract layer to the inners layer. The following Figure 3.1 depicts the research onion:

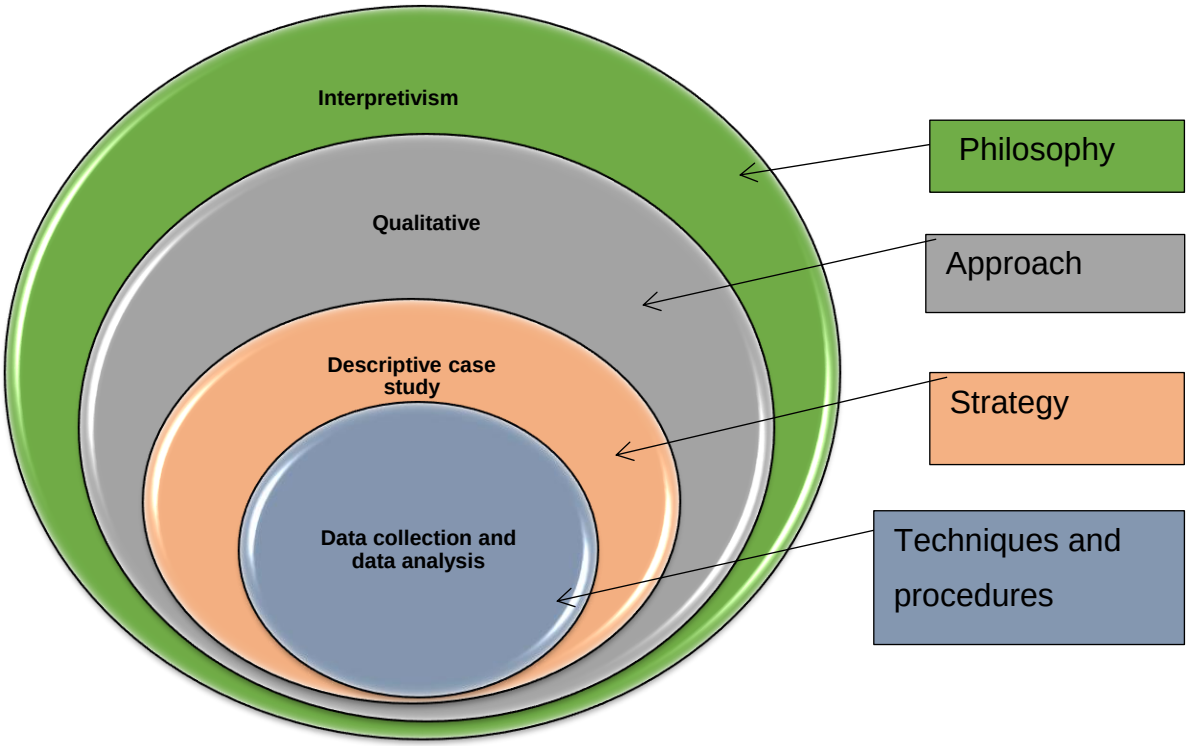


Figure 3. 1: Research onion

Adapted from: Saunders et al. (2007)

3.3.1. Philosophy: Interpretivism

The research philosophy is Interpretivism-based (Sefotho, 2016). Interpretivism has roots in hermeneutics, refer to Section 3.6.2 of Chapter 3, the study of the theory and practice of interpretation, in understanding and interpretation (Maree, 2013). In qualitative research, interpretivism is a method of investigation in which researchers must interpret what they see and hear (J. Creswell, Hanson, Clark Plano, & Morale, 2007).

In this study, the researcher collected the data through teachers' interviews, focus groups, observations, and questionnaires. This was a way of gaining understanding through discovering meanings by enhancing an individual's understanding of the whole (Strauss & Corbin, 1990). According to Maree, interpretevism recognizes the fact that realities vary (Maree, 2013) and that human life is a distinctively human product that cannot be seen from another external reality.

According to researchers Hussey and Hussey, it is imperative that, in studying social life, the researcher need to study people in their own contexts to be able to develop an understanding of the meanings they impart ” (Hussey & Hussey, 1997).

In this study, the researcher observed lessons in natural science classes of Grade 7 of two schools. In case A and B, there is the integration of ICT during teaching and learning. The researcher gathered rich insights from the participants.

3.3.2. Approach: Qualitative

This study followed a qualitative approach. The qualitative research approach is the approach that collects rich descriptive data, utilizing a variety of instruments, in respect of a phenomenon or context with the intention of developing an understanding of what is being observed or studied. “Qualitative research approach typically studies people or systems by interacting with and observing the participants in their natural environment (*in situ*) and focusing on their meanings and interpretations” (Maree, 2013, p. 25). A qualitative approach is constructionist research approach, which assumes that multiple realities are socially constructed through individual and collective perceptions of the situation (McMillan & Schumacher, 2010).

Data was collected through open ended questions in interviews and questionnaires, as well as through observations. The nature of the majority of data collected was qualitative. However, in the analysis of the data based on themes and sub-themes, an element of quantity was linked to the results, as an indication to which extent each aspect was either demonstrated, or described by participants. This is explained in section 3.5.2. To strengthen the researcher’s interpretations, some of the teacher and principal questionnaire questions (Appendix J and M) were stated such that the participant had to make these quantifying decisions themselves. The aim of the quantification was to support the constructionist approach. This allowed for the results to be represented in visual format, and to support the interpretations of the results.

Even though there is a quantitative data element in this study, it therefore is not a mixed method study. In mixed method studies, the quantitative and qualitative results converge to inform each other (Creswell, 2013). The quantitative questions in this research were not statistically analysed, and the results cannot be generalized – it

only serves to support triangulation - to inform the findings of the researcher with the view of the participants.

3.3.3. Strategy: Case study

The strategy was based on multiple case studies. “Case studies aim to analyse specific issues within the boundaries of a specific environment, situation or organization” (Dudovskiy, 2015). Case study research is a “systematic inquiry into events or a set of related events which aims to describe and explain the phenomenon of interest” (Maree, 2013). Farquhar states that: “It is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Farguhar, 2009).

It further offers “a multi-perspective analysis in which the researcher considers not just the voice and the perspective of one or two participants in a situation, but also the views of other relevant groups of actors and the interaction between them” (Maree, 2013). In case study research, “the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audio-visual material, and documents and reports) and reports a case description and case-based themes” (J. Creswell et al., 2007).

The relevance of case study in this research was that it allowed the researcher to come towards a comprehensive knowledge and understanding of how participants relate to and interact with one another in the classroom and how they make meaning of teaching and learning Science with the integration of technology. The researcher observed the integration of the ICT in teaching and learning Science in Grade 7.

The cases in this study were two schools, case A and B. The reason why the researcher has selected the two schools was because, in these two schools, the Gauteng Department of Education has started the project of a Paperless classroom. Amongst case studies, in this research descriptive case study was used.

3.3.3.1. Descriptive case study

The research strategy for this study was a descriptive case study. “Descriptive case studies aim to analyse the sequence of interpersonal events after a certain amount of time has passed” (Dudovskiy, 2015). The center of interest of descriptive case study is the broad description of whatever ideas are being researched (Hamilton & Corbett-Whittier, 2013). The researcher chose descriptive case study for this research to fully describe the data that was obtained during data collection from both cases. After the data was described it was easy reach findings. The findings give a clear understanding of what was happening in both cases. The following is the description of two cases.

3.3.3.2. Description of cases

There are two cases, school A and B. The cases in this research were the schools that were chosen by the Gauteng MEC for education to start the project of Paperless classrooms in Grade 7. Case A and B are both township schools in Ekurhuleni North district in Gauteng province. Classrooms are equipped with the latest technology such as smartboards and tablets for teaching and learning in Grade 7. The project is funded and supported by the Gauteng Department of Education. There are security personnel which are also paid by GDE patrolling the school premises day and night. Smartboards are installed in the classrooms and teachers were provided with laptops and learners received tablets. Learners’ tablets are retrieved at the end of each day for safe keeping. Technicians help the school to flush and install the tablets with new e-books for the following year.

The schools also have strong Wi-Fi. Teachers had been trained and are still receiving training on the usage of Smartboard for teaching and learning. GDE has appointed Matthew Goniwe School of Leadership to provide training and support. Each school has been allocated Interns who are stationed at the school on a full-time basis to provide technical support.

Learners in both schools are coming from the same disadvantaged socio-economic background. The schools are no fee-paying schools and rely on resource allocation funds to buy Learning and Teaching Support Materials and maintain their buildings.

The license of e-books that are installed in the tablets and Smartboards is paid for by the GDE with the money deducted from the schools' resource allocation funds.

Case A

As it has been said above, both cases were sponsored by the GDE. Case A has a second sponsor of technology which is Vodacom. Vodacom started sponsoring case A long before GDE. The Grade 7 learners have two sets of tablets, the ones provided by GDE and another set donated by Vodacom. They are both kept at school in the storage room for safekeeping and charging overnight. There are a functional computer laboratory and Wi-Fi installed by their sponsor. Matthew Goniwe and Vodacom ran training and workshops for all the teachers.

What is the Matthew Goniwe Leadership academy?

The Matthew Goniwe leadership academy is an agent that is in partnership with the Gauteng Department of Education. Its main role is to work with the teachers' development unit to provide teachers and district officials with the ICT skills they need to use the deployed ICT resources. Matthew Goniwe funds, coordinates and manages teachers' professional development.

Figure 3. 2: Case A Storage for tablets

Case B

Case B receive training from the Matthew Goniwe School of Leadership and do not have any sponsor apart from the GDE. They are resistant and lack the motivation to change into ICT integration. The ICT committee which is supposed to be identifying and organizing the training needs and workshops for teachers is dysfunctional.

Figure 3. 3: Case B Storage of tablets

3.3.4. Participants

3.3.4.1. Population and sampling

The population refers to groups/individuals that conforms to the criteria that the researcher intend to generalize through his research (McMillan & Schumacher, 2010). Out of the population of all schools that teach integrating technology, the researcher selected the two primary schools in the Paperless Classroom project as samples for cases. The population within these cases is all the teachers and the learners in the two schools, but the researcher selected two classrooms of Grade 7 Science subject teachers and learners per school. In this study, the sample was from two primary schools in the township, Grade 7 learners who are doing Science, the Science teachers, ICT coordinators, and principals.

3.3.4.2. Participants and how they were sampled

“Sampling refers to the procedure used to select a certain percentage of the population that is needed for research” (Maree, 2013, p. 79). In this study, the sampling method was stratified purposive sampling. Stratified purposeful sampling explains subcategories and enables comparison (Creswell, 2013). All learners in Grade 7 that were doing Science were sampled, those were boys and girls of age twelve to fourteen. Two teachers in case A and one teacher in case B who were teaching Science Grade 7 were selected. In case of B, only one teacher was teaching Science. ICT coordinators and principals of both schools were selected.

As indicated earlier, the study was based on two schools, where learners are learning Science using modern technology during teaching and learning. Fourteen learners were randomly sampled from the two cases for focus group interviews, seven learners per case. The workbooks and worksheets of the fourteen learners who were sampled were checked by the researcher after a focus group interview. The researcher checked the textbooks, annual teaching plans, lesson plans of Science, the nature of the assignments, the way the teachers teach the topics, policies on the use of ICT in the school and how the learners interacted with the teachers in the classrooms. Table 3.1 describes participants.

Table 3. 1: Participants

Sampled groups	Cases		Purpose
	A	B	
Teachers, teaching Science in Grade 7	2	1	Teachers are teaching natural science. The study is about integrating ICT in teaching Science to support learning. These teachers helped by supplying information needed in the study. In Case B there is only one teacher who is teaching Science in Grade 7.
All learners in both classes from both cases.	93	87	Learners will supply information on how they experience the integration of ICT in teaching.

Learners from each class.	7	7	Focus group interviews and audio recording.
ICT coordinators	1	1	Help with contextual information of the school on ICT integration.
Principals	1	1	Help with contextual information of the school on ICT integration.

All participants took part in this study voluntarily. It was explained to them that they were free to withdraw from the study at any time with no negative consequences, and a full disclosure of any associated risks was discussed with all participants. Informed consents were signed by adult participants and assent forms were signed by minors, refer to Section 1.9 in Chapter 1. The following discussion is the conceptual framework of this study.

3.4. Conceptual framework

The researcher used TPACK as the conceptual framework for this study. The conceptual framework was introduced in Chapter 2 under Section 2.8.

In this section, the researcher turns to the concept of Conceptual Framework for the study. The conceptual framework was primarily used as a lens for a deeper understanding of the complex and challenging theory of ICT integration in education specifically for Science. Existing literature illuminates that despite various means to motivate students for science, trends across developed and developing countries show a drop in interest and take-up of Science, Technology, Engineering and Mathematics (STEM) subjects (Draper, 2010). The input is necessary for addressing the problem statement and objectives for this study and for guiding data collection in the sections that follow. The conceptualization is therefore aimed at “clarification and analysis of the key concepts in the study as well as to the way this research is integrated into the body of existing theory and research” (Mouton, 2002);of the integration of ICT in science education (Draper, 2010; J. Osborne & Hennessy, 2003).

The field of ICT in education is anchored in theories of pedagogy (PCK) as per (Shulman, 1987) in Figure 2.5, with more recent technology integrated pedagogy

(TPCK) as per Mishra and Koehler (2006). The following describes the data collection process of this study.

3.5. Data collection process

There were four different types of data that were collected in this study. Table 3.2 indicates the types of data collected from participants.

Table 3. 2: Data collection process

Different instruments	Explanation	Appendix	Participants
Interviews	The researcher asked teachers questions based on themes of a conceptual framework TPCK. Interviews were audio taped and transcribed after all.	H	Teachers
Observations	The researcher observed what was happening in the whole class to compare it with what was said during interviews. The researcher used an observation schedule when observing in the class, it was according to the themes in the conceptual framework TPCK. The researcher video recorded what was happening in the class.	I	Teachers and learners
Focus group interviews	The researcher asked learners questions based on themes of a conceptual framework TPCK. Interviews were audio taped and transcribed after all.	K	Learners
Questionnaire	All teachers, ICT coordinators, and principals answered questionnaires.	J, L, and M	Teachers, ICT co-ordinators, and principals.

Figure 3.4 depicts the data collection process that was followed by the researcher.

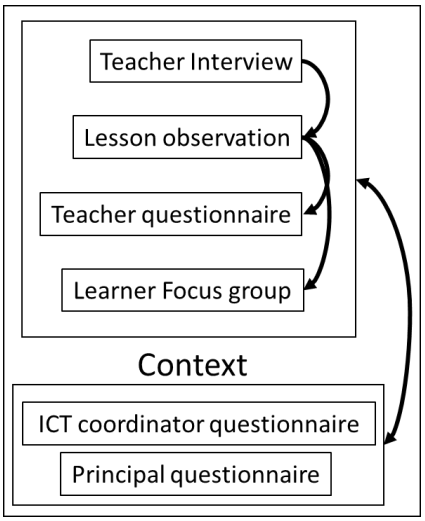


Figure 3. 4: Data collection process

The data collection process was applied in the same way in both cases. Figure 3.4 represents how the data collection process was followed in both cases.

3.5.1. Teachers' interview

The researcher started with interviewing teachers, the reason of interviewing teachers first was to find out what teachers would say about ICT integration. For interview questions refer to Appendix H. The aim of this study was to find teachers' attitudes, challenges, and benefits in ICT integration. The researcher followed with lesson observations.

3.5.2. Lesson observation

The lesson observations were the follow-ups for the teachers' interviews. The researcher aimed to observe what was taking place during the lesson presentations and see if what was said during interviews was taking place in the classroom during ICT integration. For the observation schedule refer to Appendix I, Teachers' completed questionnaires.

3.5.3. Teachers' questionnaire

Questionnaires were completed by the teachers after the lesson observations as per Appendix J. The questionnaires supplied the researcher with more information

concerning the attitudes of teachers towards ICT integration, challenges that teachers encounter during ICT integration and benefits from ICT integration. Questionnaires helped the researcher to get information from the teacher, the researcher had to look at the flow of information from the teachers' interview, to lesson observation up to the questionnaire. The data collected helped the researcher to interpret the results. The Learner sat for focus group interview.

3.5.4. Focus group for learners

A group of seven learners from each case sat for focus group interviews, refer to Appendix K. Learners were randomly selected after the lesson observation. Learners answered questions in a group form. Each learner who had an answer was given an opportunity to voice it out. Not that all learners were supposed to answer all questions. Answering of question was voluntarily depending on learners wanted to answer the question. The aim of the researcher was to find information from learners concerning their attitudes, benefits, and challenges towards ICT integration. Learners were observed in the class during the lesson observation. The researcher aimed to find out if the learners were involved in using ICT resources and to check how much they participated in the class.

3.5.5. ICT co-ordinators' questionnaire

ICT co-ordinators of both cases answered the questionnaires. The aim of the researcher was to find out the view of the ICT co-ordinator concerning ICT integration in their schools, for questionnaires refer to Appendix L. The data gathered from the ICT co-ordinators helped the researcher to have more information on the context of the cases.

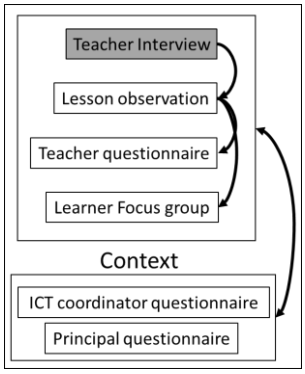
3.5.6. Principals' questionnaire

Principals of both cases answered the questionnaires. The aim of the researcher was to find out the view of principals concerning ICT integration in their schools, for questionnaires refer to Appendix M. The data gathered from the principals helped the researcher to have more information on the context of the cases.

3.6. Data collection instruments

Data was collected via interviews, focus group interviews, observations and questionnaires. In all the instruments the researcher wanted to get the broader understanding of the attitude, challenges and benefits of ICT integration from the participants and the TPACK was used as the lance through which data was analysed. The researcher gathered the data by observing the lessons taking place during Science classes using audio recordings. There were teachers' interviews after the lessons. The researcher wrote down field notes and audio recorded interviews.

Semi-structured focus group interviews were conducted to collect qualitative data from learners regarding their perceptions on TPACK. Semi-structured interviews (interviews that organize "around areas of particular interest, while still allowing flexibility in scope and depth") was used in this study (De Vos et al., 2014). One-to-one un-structured interviews were used to collect data from the individual teachers who were participating in this study. The questions were generated from the themes in the conceptual framework TPACK. The following are the different types of data collection instruments that were used in the study.



3.6.1. Interview with the teachers

According to Maree: "the interview is the two-way conversation in which the interviewer asks questions to collect data and to learn about the ideas, beliefs, views, opinions, and behavior of the participants" (Maree, 2013, p. 87). In this study structured and recorded interviews were administered to teachers. Questions that were used during the interview were detailed and developed from the conceptual framework of the study. The teachers' interviews were one-to-one. The conceptual framework of the study was

technological knowledge, pedagogical knowledge and the effect of content knowledge that was taught at that time for teachers. During interviews, the researcher audio recorded the interviews to get more data for validity and reliability purposes. Teachers were interviewed for fifteen minutes each. Refer to Appendix H for the interview questions. The following is the figure that was used to categorize questions into the TPACK. Figure 3.5 categorizes the questions for teachers' interviews.

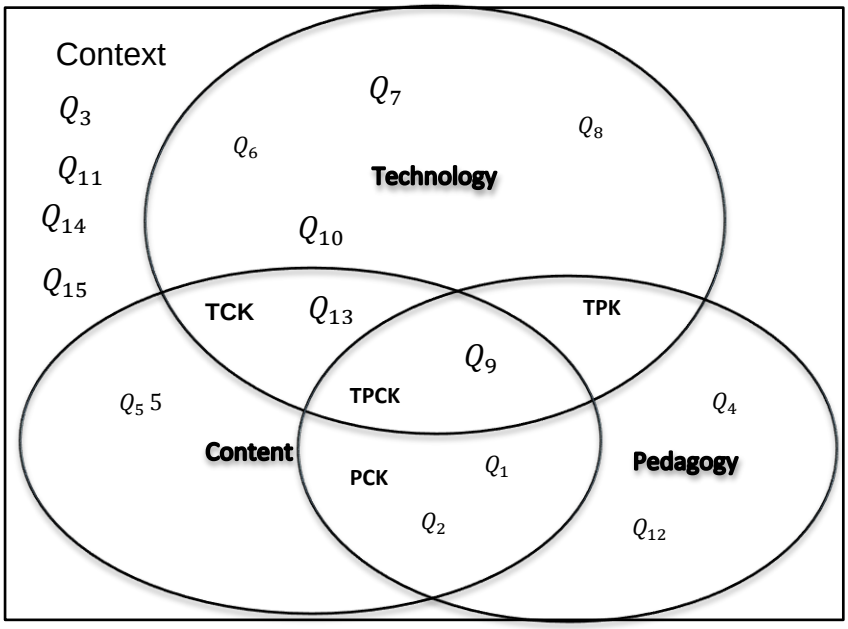
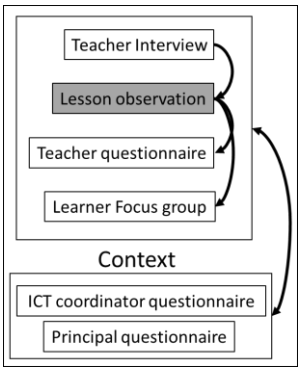


Figure 3. 5: Interview questions for teachers

Figure 3.5 is the summary of the categories per questions. The teachers' interviews had fifteen questions. The interviews schedule is reflected under Appendix H. Questions 6, 7, 8 and 10 focused on the technology knowledge. Question 6, 7, 8 and 10 focused on finding out about the implementation of ICT, types of equipment that were used during implementation and technical support teachers receive from ICT technicians during integration. Question 4 and 12 focused on the pedagogical knowledge of teachers. The researcher aimed to find out how much time teachers had to use ICT to plan their work and their benefit in terms of technician's assistance that could help teachers to acquire pedagogical knowledge to implement during ICT integration in class.

Question 5 focused on the content knowledge. The researcher wanted to find out if teachers had in depth knowledge on science so that it would be simple for them just to implement ICT in teaching it. Question 13 focused on knowledge of content (TCK) and how to integrate ICT in teaching natural science. Question 1 and 2 focused on the PCK. With question 1 and 2, the researcher could find clarity on teachers' pedagogical and content knowledge of Science. Question 9 focused on the TPACK. Question 9 helped the researcher to find out from the teachers' point of view about how they viewed everything about ICT integration, their attitudes, challenges and benefits. Questions 3, 11, 14 and 15 focused on the context. The researcher found out about the context of the school concerning the ICT integration, looking at the availability of policies on ICT integration, leadership vision on ICT integration, problems the schools encountered while integrating ICT and what they thought could be done to address the problems. The following sub-section is for lessons observations.

3.6.2. Observations



"Observation is the systematic process of recording the behavioral patterns of participants, objects, and occurrences without necessarily questioning or communicating with them" (Maree, 2013, p. 83). "It is a way for the researcher to see and hear what is occurring naturally in the research site" (McMillan & Schumacher, 2010). The researcher observed the lessons with the aim of gaining insight and understanding of the occurrences without participating in the lesson. During the observations, the researcher made sure that there was no bias, but that the lesson was observed holistically. During observation, the researcher video recorded the lesson to get more data in pursuit of validity and reliability purposes. The researcher watched the video over and over with the conceptual framework in mind and filling in

the observation sheet. The researcher gathered the data without obstructing activities by observing the lessons taking place during natural science classes. The researcher used an observation schedule that was informed by themes in a conceptual framework. The researcher watched videos repeatedly and filled in observation schedule according what was happening in the videos.

For this study, the conceptual framework was based on the technological knowledge (TK) of the teachers who were involved in the study, their pedagogical knowledge (PK) and content knowledge (CK). The content knowledge (CK) in the recent curriculum is standardized, teachers are teaching according to the policy documents of different subjects. The study was on the content knowledge of the lesson that was presented during the observation, not on general teachers' content knowledge of Science as the subject. Each class was observed for thirty minutes. Refer to Appendix I for the observation schedule. Figure 3.6 categorizes the questions for lessons observation.

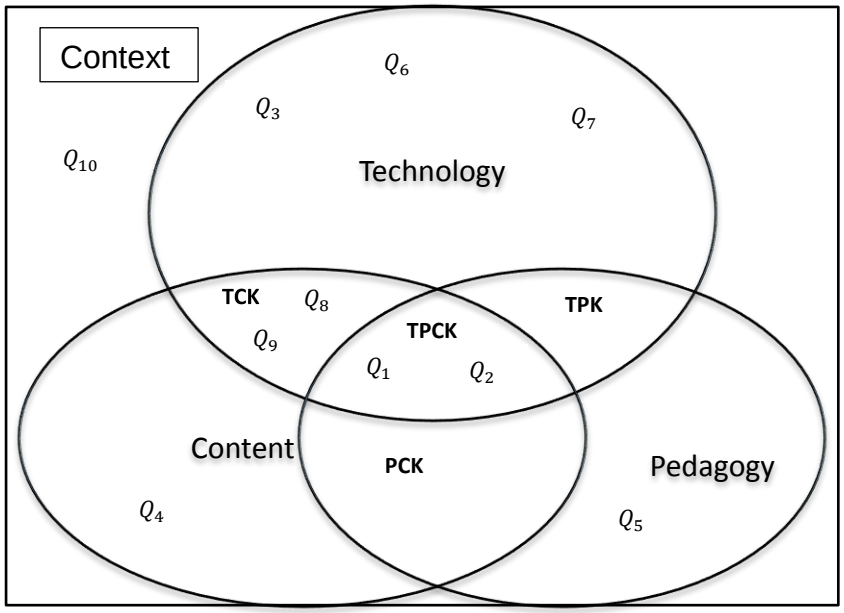


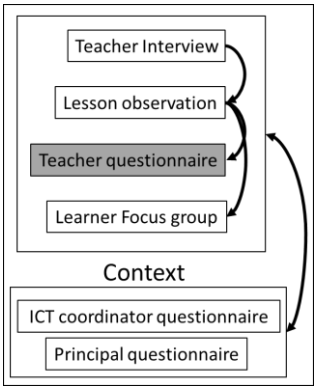
Figure 3. 6: Lesson Observation

Figure 3.6 is the summary of the categories per questions. The lesson observations had ten questions. The observation schedule is reflected under Appendix I. Question 3, 6 and 7 focused on the technology knowledge. With question 3, 6 and 7 the researcher aimed to find out the type of ICT resources that were available in the class during the lesson presentation, which ones were used during the lesson presentation

and to find out if resources were reliable for the teachers and learners to use successfully. Question 5 focused on the pedagogy knowledge. The researcher aimed to find out the method of teaching that was used by the teacher during lesson presentation.

Question 4 focused on the content knowledge. The researcher aimed to find out about the content/topic that was taught during the lesson presentation and the knowledge of the teacher on how to integrate content in ICT. Questions 8 and 9 focused on the TCK. The researcher aimed to find out if technological resources were used appropriately during content delivery and whether the learners were fully involved to used ICT resources during the lesson. Question 1 and 2 focused on TPCK. The researcher aimed to find out if the lesson presentation engraved ICT integration. The lesson was observed from the introduction up till the end if ICT was integrated. Question 10 focused on the context. The research looked at the context of the class during the lesson presentation if the class was conducive for proper ICT integration. The following describes the teachers' questionnaire.

3.6.3. Teachers' questionnaires



Questionnaires, organized via interviews, provide depth of understanding and insights into the beliefs, attitudes, and opinions of the research participants. Questionnaires can give the researcher a broader understanding of the issues at stake allowing the possibilities of following a systematic order in generating information (Hamilton & Corbett-Whittier, 2013, p. 108). All teachers from both schools answered the questionnaires. Refer to Appendix J for the teachers' questionnaires. Figure 3.7 categorizes the questions for teachers' questionnaires.

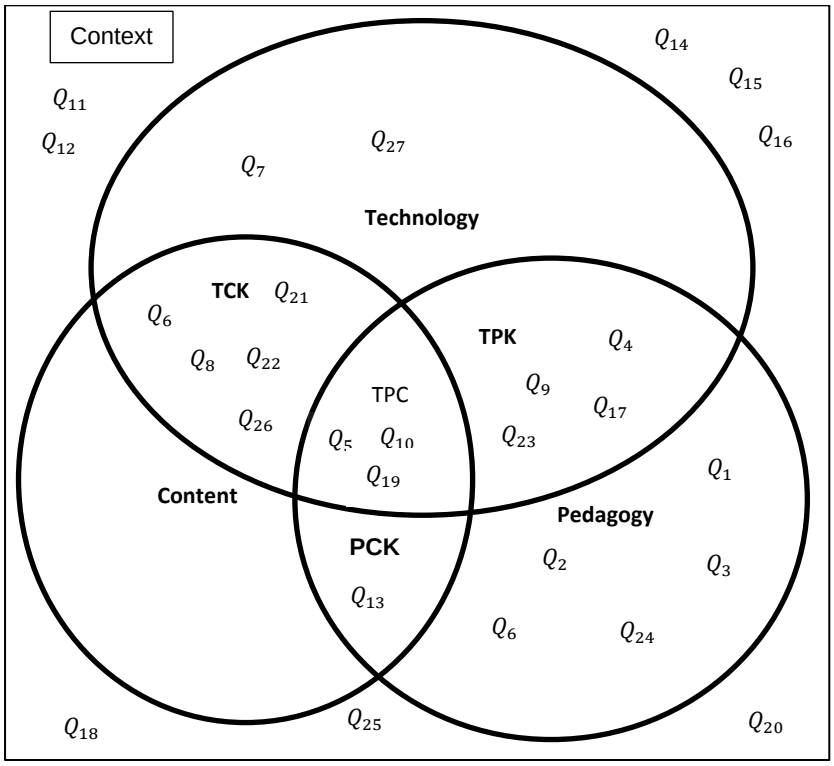


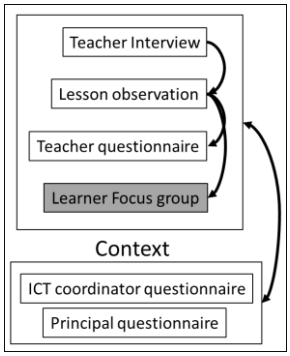
Figure 3. 7: Teachers' Questionnaire

Figure 3.7 a summary of the categories per questions. The teachers' questionnaires had twenty-seven questions. The questionnaire schedule is attached under Appendix J. Questions 7 and 27 focused on the technology knowledge. The researcher aimed to find out the technology knowledge of teachers and their attitudes towards ICT integration in science. Questions 1, 2, 3, 6 and 24 focused on the pedagogy knowledge. These questions helped the researcher to find out about the preferred method of teaching natural science integrating ICT. Question 6, 8, 21, 22 and 26 focused on the TCK. These questions helped the researcher to find out how the technological knowledge of teachers provided an input in ICT integration and assisted the teaching and learning of natural science.

Questions 4, 9, 17 and 23 focused on the TPK. These questions helped the researcher to find out the attitudes of teachers towards ICT integration that would help them in implementing their technological pedagogical knowledge. Questions 5, 10 and 19 focused on the TPCK. These questions helped the researcher to find out about the technological pedagogical content knowledge, they led to finding out about attitude,

challenges, and benefits in ICT integration. Questions 11, 12, 14, 15, 16, 18, 20 and 25 focused on the context. These questions helped the researcher to find out more about the context of the cases concerning ICT integration, support from school management in ICT integration, support from the Department of Education, barriers/challenges teachers and learners encounter during ICT integration in or outside the classrooms, guidelines on ICT integration and benefits to the school as the results of ICT integration.

3.6.4. Focus group interviews with the learners



Learners were asked to sit for focus group interviews. The researcher collected in-depth qualitative data about the perspectives, attitudes, and experiences of learners about the impacts of technology integration in their learning of natural science. Funnel structure model was used when setting questions for the learners. According to Maree (2013, p, 91) 'funnel structure is when you would start with broad and less-structured set of questions to ease the participants into the situation'. The learners were interviewed in focus groups after the lessons. During observations, the researcher video recorded in order to find out what learners are doing in the class so that she can relate to what they would say during the interviews to obtain data for analysis purposes. "Focus group interviews are likely to provide ample information within a short period while avoiding one-to-one soliciting of information, which could be intimidating to some of the learners" (Kazeni, 2012, p. 67). Learners sat for focus group interviews for thirty minutes. Refer to Appendix K for focus group interview questions. Figure 3.8 categorizes questions for the focus group interviews.

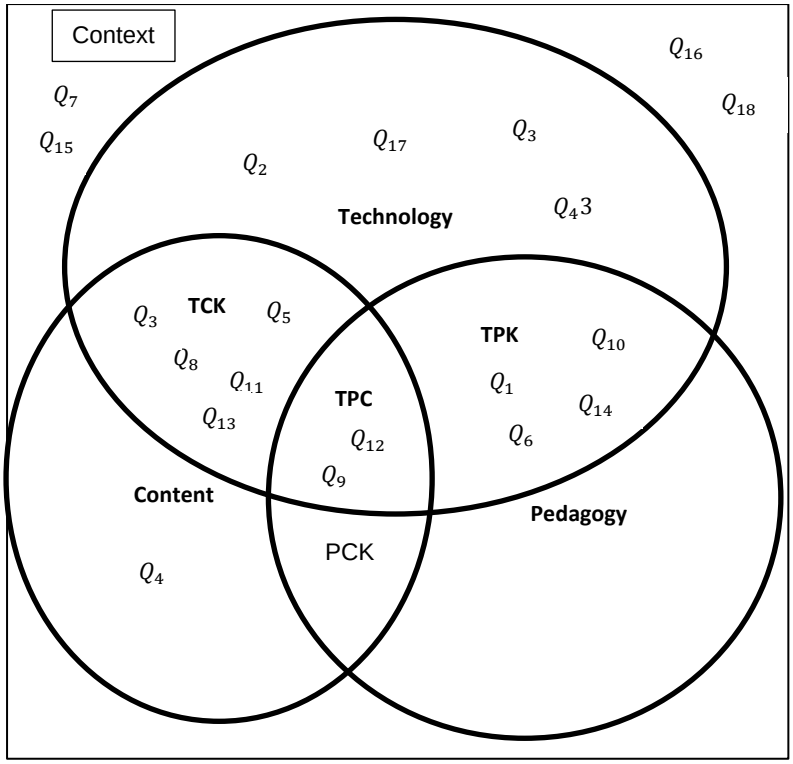
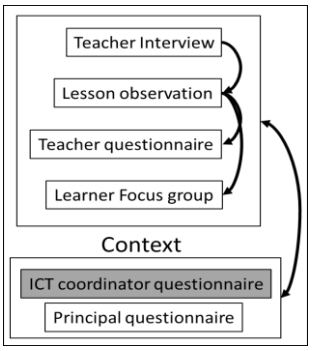


Figure 3. 8: Learners' focus group interviews

Figure 3.8 is the summary of the categories per questions. The learners' focus group had eighteen questions. The focus group schedule is attached under Appendix K. Questions 2, 3, 4 and 17 focused on the technology knowledge. The researcher aimed to find out from the learners which technological resources they used in the class during ICT integration in natural science and to find out about the knowledge learners must have to use the resources. No question focused on the pedagogy knowledge. Learners were not asked about the pedagogical knowledge of their teachers. Question 4 focused on the content knowledge. The aim of researcher was finding out if learners achieved in depth knowledge in natural science because of ICT integration. Question 3, 5, 8, 11 and 13 focused on the TCK. These questions helped the researcher to find out the attitude of learners towards ICT integration and learners' benefit when ICT is integrated in Science. No question was based on the PCK. Questions 1, 6, 10 and 14 focused on the TPK. These questions focused on the technological pedagogical knowledge but from learners' point of view, the reason being that learners are the ones who are experiencing what is happening in class during their lessons where ICT is integrated in Science. Questions 9 and 12 focused on the TPACK. The researcher aimed to find out the impact of ICT integration onto the learners. Questions 7, 15, 16

and 18 focused on the context. The researcher aimed at finding out how learners were viewing the context of the school in terms of integration of ICT, their frustrations, benefits, and recommendations. The following is for ICT co-ordinators.

3.6.5. ICT coordinators' questionnaire



All ICT coordinators from both schools answered the questionnaires. Refer to Appendix M for the questionnaires. Figure 3.9 categorizes questions for ICT coordinators' questionnaires.

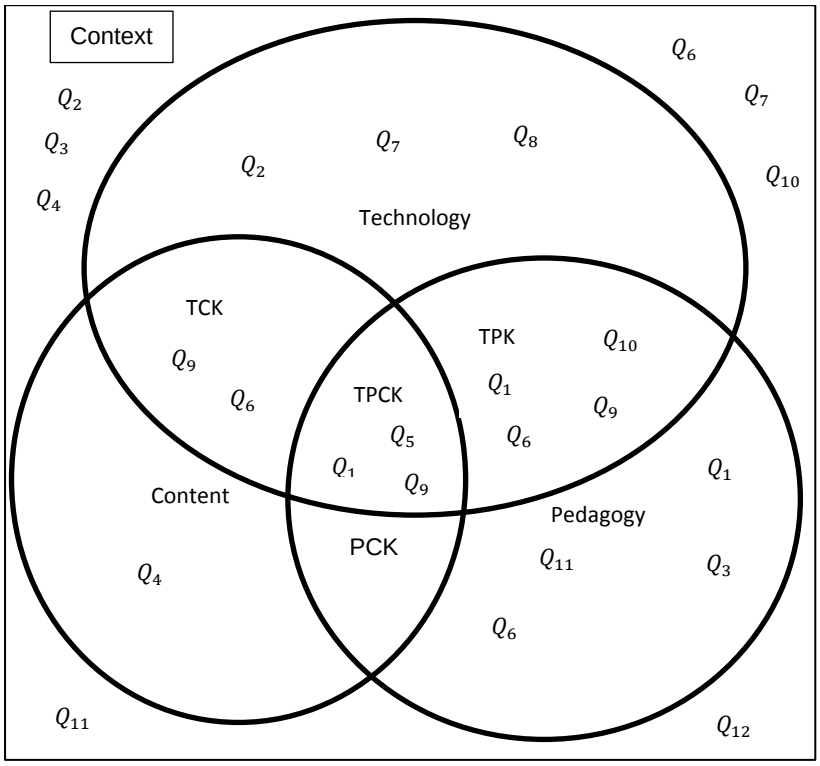
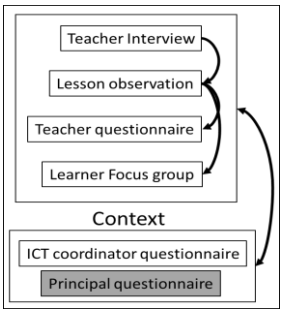


Figure 3. 9: ICT coordinator's questionnaire

Figure 3.9 is the summary of the categories per questions. The ICT co-ordinators' questionnaires have twelve questions. The questionnaire schedule is attached under Appendix L. Questions 2, 7 and 8 focused on the technology knowledge. Question 1, 3, 6 and 11 focused on the pedagogy knowledge. Question 4 focused on the content knowledge. Questions 6 and 9 focused on the TCK. Questions 1, 5 and 9 focused on the TPACK. Questions 2, 3, 4, 6, 7, 10, 11 and 12 focused on the context.

3.6.6. Principals' questionnaire



Principals from both schools answered the questionnaires. Refer to Appendix N for the questionnaires. Figure 3.10 categorizes questions for principals' questionnaires.

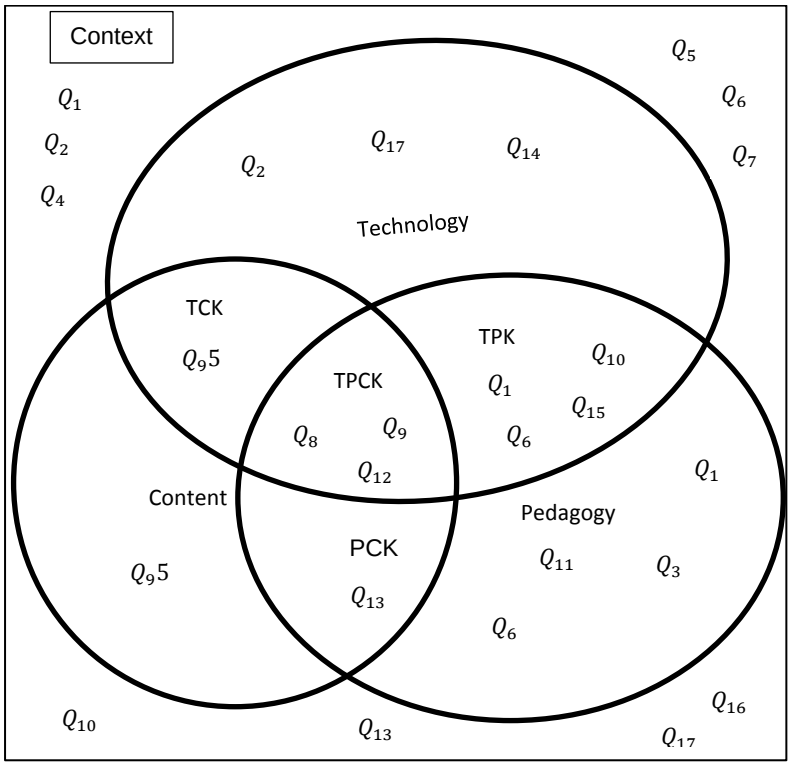


Figure 3. 10: Principal's questionnaire

Figure 3.10 is the summary of the categories per questions. The principals' questionnaires had seventeen questions. The questionnaire schedule is attached under appendix M. Questions 2, 14 and 17 focused on the technology knowledge. Questions 1, 3, 6 and 11 focused on the pedagogy knowledge. Question 9 focused on the content knowledge. Question 13 focused on PCK. Question 8, 9 and 12 focused on the TPACK. Questions 1, 2, 4, 5, 6, 7, 10, 13, 16 and 17 focused on the context.

3.7. Data Analysis

"Data analysis involves organizing the raw or unprocessed answers from the interviews and field notes and developing themes and highlights found within them" (De Vos et al., 2014, p. 359).

The raw data that was generated in this study was transcribed and analysed while still fresh in researcher's mind. As indicated earlier, the researcher used six themes as identified from the conceptual framework. The themes were Technological (T), Pedagogical (P) and Content (C) of what was taught at that time, as well as Technological pedagogical (TP), Technological content (TC) and Technological pedagogical content (TPC) knowledge. The performances of the teachers and the learners in terms of the above themes were analyzed in form of graphs and charts.

The qualitative data analysis of the data, however, was largely an inductive process of organizing the raw data obtained into categories and identifying patterns and relationships among them. This was how the researcher synthesized the data to make meaning from it (McMillan & Schumacher, 2010).

3.7.1. Analysis of the data with an example

Table 3.3 is an example of every data collecting instrument in this study. The researcher created the table according to the different type of data collection instruments that were used in the study. The table for teachers' interviews has fifteen columns because the instrument has fifteen questions. For all other instruments, their columns would be according to their questions. All tables have ratings from **1-5**. Rating are as follow:

1 for poor, the participant would get poor if their response was negative **(strongly disagree / none / little)** towards the statement;
2 for fair, the participant would get fair if their response was between negative and positive towards, or if they **disagreed** with the statement;
3 for moderate, the participant would get moderate if their response is **neutra**l / **neither agree nor disagree / average** towards the statement;
4 for good, the participant would get good if their response was **positive or if they agreed** with the statement; and
5 for excellent, the participant would get excellent if their response was **highly positive** or if they **strongly agree** or implied **a lot/many**.

In the results chapter these numbers are incorporated in the summary of results of each instrument.

Table 3. 3: Results of data collection instruments

Questions	Ratings				
	1	2	3	4	5
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Table 3.3 is an example of a table that appears to each participant to show their responses from the different data collection instruments. As it was explained above the number of columns differs according to the number of questions of the different instruments.

The participant got a tick for each answer under the rating. The researcher then changed each tick to 1 to find the total per column in other to create the graph for each participant. The following is the table where the researcher changed ticks into the 1's. There is total per column and percentage as well.

Table 3. 4: Scoring example

Questions	Ratings				
	1	2	3	4	5
1		1			
2		1			
3			1		
4		1			
5					1
6			1		
7					1
8				1	
9				1	
10				1	
11				1	
12			1		
13				1	
14		1			
15			1		
Tot		**4**	**4**	**5**	**2**
%	0%	27%	27%	33%	13%

Under rating 1 there was no tick and so the participant got 0%, for rating 2 the participant got 4 ones which give 27%, for rating 3 the participant got 5 ones which give 33% and for rating 5 there are 2 ones which is equivalent to 13%. The total percentage is 27% + 27% + 33% + 13% which sums up to 100%. The percentages are then used to generate the graph.

Figure 3.11 is an example of the graphs of every participant. The graph illustrates the analysis of results.

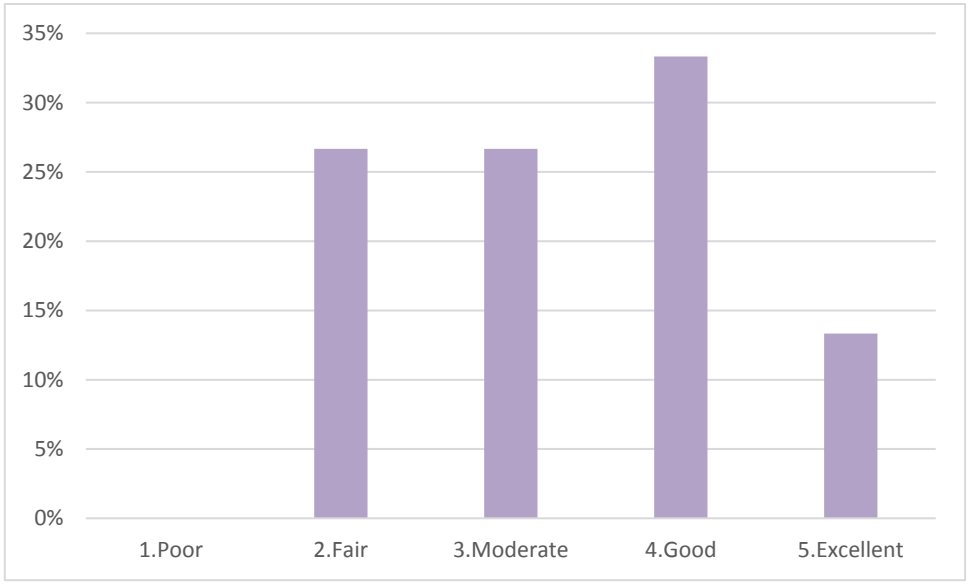


Figure 3. 11: Graph for analysis

Figure 3.11 represents the results of the participants in each data collecting instrument they have responded to. All the graphs look the same, the only differences would be the results according to the respondents and colours. The graphs for all respondents in case A are blue and case B are orange in color.

3.7.2. The hermeneutics principles

The researcher presented the data with tables and figures according to the themes. Descriptions of the findings were based on the two cases. The observed similarities and difference between and within the two cases are found with the relevant interpretation of graphs in Chapter 5.

To ensure the reliability of the collected data, the researcher considered seven principles of hermeneutics. This was done to make sure that collected data that was interpreted were the stories from the side of the participants but not the researcher's view.

The following Table 3.5 explains the principles of hermeneutics and how they were used in this study.

Table 3. 5: Principles of hermeneutics

Source: Klein and Myers (1999)

Principles of hermeneutics	**Meanings of principles**	**How the principles were used in this study**
Hermeneutic circle principles	This principle suggests that human understanding is gained by acquiring more knowledge of individual fragments and by putting those fragments together to be one huge knowledge that can benefit the study.	-The researcher listened to what participants were saying during interviews. The context of each participant was taken into consideration, to sum up for results. The researcher observed lesson presentations. Teachers, ICT co-ordinators and principals answered questionnaires. The researcher interpreted what was said and done during data collection. The researcher visited the cases to discuss the interpreted data to determine if it was exactly what they meant.
Contextualization	The principle talks of the context of the cases.	-The researcher went to the cases before data was collected to submit consent letters. Whilst talking to the management (principal and head of department in sciences) of the cases, the researcher figured out a little bit about the contexts of the cases. The cases' historical and social background were discussed with the researcher. The reader was provided with the contexts of both cases, refer to Section 3.3.3.1 of the methodology chapter.
Researchers and the subjects.	The principle speaks of the interaction between the researcher and the participants.	The researcher interacted well with the participants. Firstly, it was for the participants to understand their rights in being part of the research. Secondly, it was to let the participants to be open and talk to the researcher. The researcher wanted to get the best message from the participants. Teachers and learners were interviewed.
Abstraction and generalization.	The principle focuses on putting together interpreted	After all the data was collected, the researcher interpreted different data and put things together to find results,

	data to hypothesise the results.	it was done to generate a theory for the study.
Dialogical reasoning.	The principle speaks of responsiveness of the researcher to contradictions between theory and actual findings.	The researcher did the finding according to what the data was saying. Summary of results was done according to the data. Nothing was added from the researcher's point of view. The researcher's expectations did not affect outcomes of the study.
Multiple interpretation.	The principle addresses the consciousness in mixing the data from different participants during data interpretation.	-The researcher listened sensitively to all participants and got the actual message for proper interpretation. Each participant's context was well considered when all the data was interpreted.
Principle of suspicion	The principle focuses on the responsiveness on the unfairness during data collection where irritation is caused to any participant due to unforeseen circumstances. The researcher avoided to be biased during the study.	-The researcher made sure that anything that was irritating some of the participants was not taken into consideration. For example, Wi-Fi connections gave most of the teacher's problems, causing irritation. The researcher supervised that participants were treated as initially planned.

The researcher considered all the principles of hermeneutics because this study is interpretive research. The contextual factors of the cases were to be considered and the in-depth actual information concerning ICT integration in the cases was vastly important.

3.8. Ethical Considerations

Research ethics relates to "the appropriateness of the researcher's behavior in relation to the rights of those who become the subject of a research project, or who are affected by it" (Bull, 2004); Saunders et al., 2009, p. 600). The following covers the ethical implication of data collection strategies.

3.8.1. Gauteng Department of Education

The researcher applied for the permission from the Gauteng Department of Education to conduct the study at two primary schools in Tembisa. Two primary schools are part

of a project that was initiated by an MEC to introduce Paperless classrooms. The permission was granted to the researcher to continue with the study, refer to Appendix B. According to the GDE research approval letter, the validity of research approval was from 6 February 2017 to 29 September 2017.

3.8.2. University

The researcher applied for ethical clearance from the University. The Faculty of Education Ethics Committee approved the application on the 8th of February 2017, refer to Appendix B. The researcher was granted the permission to continue with fieldwork.

3.8.3. Permission

The researcher asked permission to conduct the study from the Department of Education, principals of the schools, teachers, parents, and learners. Letters of permission were written to the Department of Education and principals of both schools where the study was conducted. Informed consents were signed.

Informed consent

Informed consent was obtained by providing participants with a description of the research, a chance to withdraw from the study at any time without any negative consequences, and full transparency in relation to any risk related to the study. Obtaining informed consent implies that all possible data on the goal of the inquiry, the procedures, the thinkable advantages, disadvantages and danger to which the participant may be exposed are made clear to the participant (De Vos et al., 2014). Teachers and parents of the learners who were participating in the study signed the informed consent form. The consent is usually obtained by asking subjects (or parents of the minor subject) “to sign a form that specifies an understanding of the study and consent to participate” (McMillan & Schumacher, 2010).

Assent form

Assent is typically obtained from minors who are old enough to understand that they are agreeing to participate and may choose not to do so without penalty (McMillan & Schumacher, 2010). The ages of learners who participated in the study were from twelve to fourteen years. All participants were assured of safety.

3.8.4. Safety in participation

Participants were protected against harm, they were thoroughly informed beforehand about the potential impact of the investigation (De Vos et al., 2014). Research never resulted in physical or mental discomfort, harm, or injury to the participants (McMillan & Schumacher, 2010).

The researcher made sure that there was no harm or risk to participants. There would be no information that was revealed during and after the study that would bring embarrassment, danger or any negative consequences to participants. There was privacy.

3.8.5. Privacy

The participants were assured of privacy. The researcher ensured privacy by using three practices, namely:

- Anonymity means that the researcher cannot identify the participants from information that has been gathered.

- Furthermore, “confidentiality means that no one has access to individual data or the names of the participants except the researchers and that the subject known before they participate who will see the data” (McMillan and Schumacher 2010 p. 121).

- Appropriate storing of data means that the collected data, including paper copies of responses and electronic forms of data, will be stored safely within the reach of the researcher only, in a way to provide a maximum protection of the participants’ identities.

The video recording will not be published but would only be seen by the researcher and the supervisor. In case a video recording is used, the learners’ faces would be covered to avoid their identification. An audio recording would also be available only for the dissertation by the supervisor and researcher for office purposes.

3.8.6. Voluntary Participation

Participants were not forced to take part in the study. The researcher told the participants that they could choose to participate or not participate, but the implicit message that, you are letting us down if you do not participate was also clear and compelling (McMillan & Schumacher, 2010). Permission was asked by the researcher.

3.8.7. Trustworthiness of collected data

Trustworthiness is dependent on the terms set out below.

Terms	**Definition**	**How was implemented in this study**
Dependability	This refers to the way in which the collection of data can give the same results if it was repeated in the same manner. This speaks to the constancy of the data gathering over the time and over the settings of the study.	After data was collected from the participant, transcription was done, and the researcher went back to the participants to find out if that was what they meant, refer to appendices O to S.
Transferability	This is referred to as external validity and is the ability to apply one study to other situations. The extent to which findings are valuable to a person in another settings differs for another research in that readers determine how appropriate the findings are to their situations.	Stratified purposeful sampling was done in this study. All learners in Grade 7 that were doing Science were sampled, those were boys and girls of age twelve to fourteen. Teachers who were teaching Science in Grade 7, ICT coordinators and principals, refer to Section 3.3.4.
Credibility	This refers to internal validity by ensuring the data collection instruments were measuring what the study aimed to investigate. The certainty in the truth of the study and	The researcher used instruments to collect data, anyone else can use the same instruments attached under Appendix I-M. The findings are from the data that

	therefore the results are the most important outcome of the study.	was collected from the participants, nothing from the side of the researcher.
Confirmability	This refers to the researcher's objectivity. The neutrality or the degree to which findings are consistent and could be repeated. The findings should be based on what was collected from participants, nothing should be contributed by researcher bias.	The findings are from the collected data. Nothing that is from researcher's point of view is reflected in the findings of this study.

During the data collection, video and voice recordings were done and the participants were not being compromised. The video recording would not be published but would be seen by the researcher and the supervisor only. In case the video recording is used learners', faces will be covered to avoid identification.

3.9. Conclusion

This chapter has indicated the problem statement from general issues to specifics concerning how the object of study (the problem, the intransitive object) was tackled through the research process (the transitive object). The study questions and related objectives of the study have been indicated. The chapter has also paid attention to the theoretical and conceptual framework related to the study objectives. This was followed logically by the methodology to be used to collect and analyse information to relate to the study objectives which was guided by research onion. Finally, the ethical issues associated with the study were spelled out. The following chapter presents the results of the study.

Chapter 4

- 4.1 Introduction
- 4.2 Research problem and question
- 4.3 Results
- 4.4 Case descriptions
  - 4.4.1 Teachers's interviews
  - 4.4.2 Lessons observations
  - 4.4.3 Teachers' questionnaires
  - 4.4.4 Learners' focus group
  - 4.4.5 ICT co-ordinators' questionnaires
  - 4.4.6 Principals' questionnaires
- 4.5 Conclusion

4. Results

4.1. Introduction

This chapter presents the empirical results from the field of study as the data collected through teachers' interview, lesson observations, learners' focus group interviews and questionnaires for teachers, ICT coordinators and principals are presented. It outlines a descriptive layout of the data collected from two Paperless primary schools, case A and case B, that are currently piloting the implementation of ICT such as smartboards and tablets for teaching and learning in Grade 7. Data was collected from Science lessons. The data was analyzed qualitatively. The collected data was organized into categories and identified into patterns to highlight relationships. The raw transcribed data is reflected in appendices O to S. Data was analyzed using graphs to arrive at meaningful conclusions.

4.2. The research problem and question

The main purpose of this research is to study the experiences of teachers and learners in Grade 7 Science in township schools in the Paperless project.

To provide rich information in understanding the implementation process of ICT the research sought to find out:

- How is ICT integration into the Grade 7 Science classroom in the Paperless classroom project?
- Which challenges did the participants experience during implementation?
- How did the implementation benefit the teaching and learning processes?

4.3. Results

The raw data that was generated in this study was transcribed and analysed while still fresh in researcher's mind. See from Appendix O to S. As indicated in Section 3.1, the researcher used six themes as identified from the conceptual framework. The themes are Technological (TK), Pedagogical (PK), Content (CK) (of what was taught at that

time), Technological pedagogical (TPK), Technological content (TCK) and Technological pedagogical content (TPCK) knowledge. The performance of the teachers and the learners in terms of the above themes were analyzed in terms of statistical deviations from the expected output or performance of case A and case B.

Firstly, the researcher started by interviewing two Grade 7 teachers from case A and one teacher from case B, observing Science lessons of the same teachers and conducting focus group interviews with seven Grade 7 learners per case, while the same teachers per school, the ICT coordinators and principals completed questionnaires

Order of data collected and purpose of each instrument

4.3.1. Teachers' interview

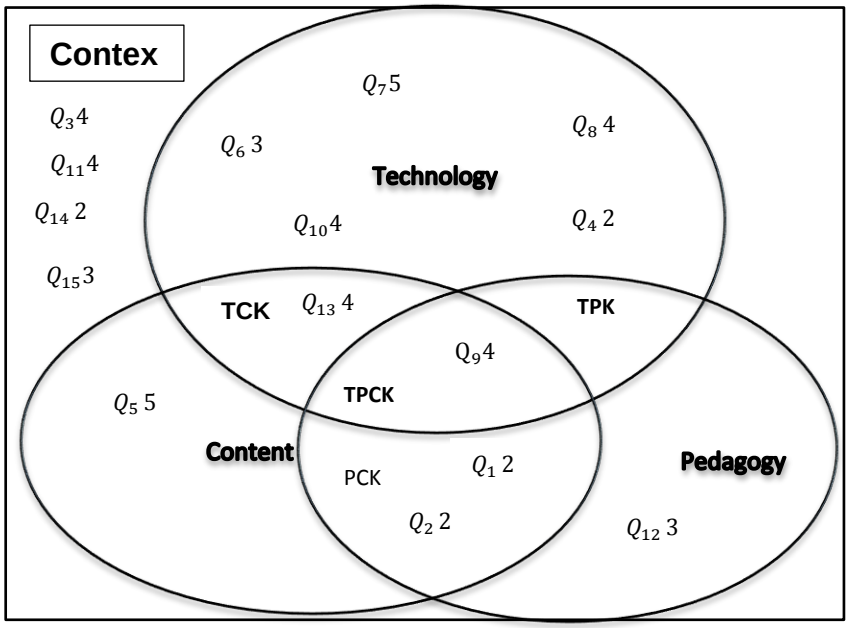
The first data collection instrument for this study the researcher used was teachers' interviews, as explained in Chapter 3. This section explains the results from the data collected from the teachers' interviews, conducted with the Science teachers from both cases. The researcher outlined the data according to questions, descriptions and codes to different responses.

Presentation of data

The following figures are the presentation of data collected from the three teachers as per Table 3.1. Interview questions are reflected in appendix H. Teachers were asked questions based on the use of ICT in the classroom. The questions focused on the attitudes, benefits, and recommendations of teachers on the use of ICT in teaching natural science in Grade 7. The questions were categorized within the TPACK framework as per Figure 2.5.

The table represents the ratings per question, as explained in section 3.7. Questions were rated from 1 – 5. Rating 1 is poor, for any negative answer the teacher gave; 2 is for fair, 3 is for moderate; 4 for good; 5 for excellent. Inside the figure are questions answered during the interview (Q_1 -$Q_{15)}$, and the ratings per interview questions that explain the mark that was allocated to the question.

Figure 4.1 represents the results of interview questions of teacher A in case A.



Questions	Ratings				
	1	2	3	4	5
1		√			
2		√			
3				√	
4		√			
5					√
6			√		
7					√
8				√	
9				√	
10				√	
11				√	
12			√		
13				√	
14		√			
15			√		

Figure 4. 1: Case A teacher A interview

The results for teacher A are as follows:

TK: Q4 – Fair; Q7 - Excellent; Q8 and 10 – Good; Q6 – Moderate.

- Teacher A is in the school where there is support in ICT integration from the school management side, they attend training on the use of ICT, that is the reason why her technology knowledge is good. As per discussion under sub-section 2.1.2.1 in chapter 2, teachers need development to acquire more skills and knowledge on ICT resources.

PK: Q12 - Moderate.

- The pedagogy knowledge of teacher A is on moderate because she has only started ICT integration three years ago. More support is needed on her pedagogy knowledge.

CK: Q5 - Excellent.

- Teacher A knows the content very well.

TCK: Q13 - Excellent.

- Teacher A is excellent when using technology to teach the content.

PCK: Q1 and 2 – Fair.

- She needs more support on the methods of teaching using ICT.

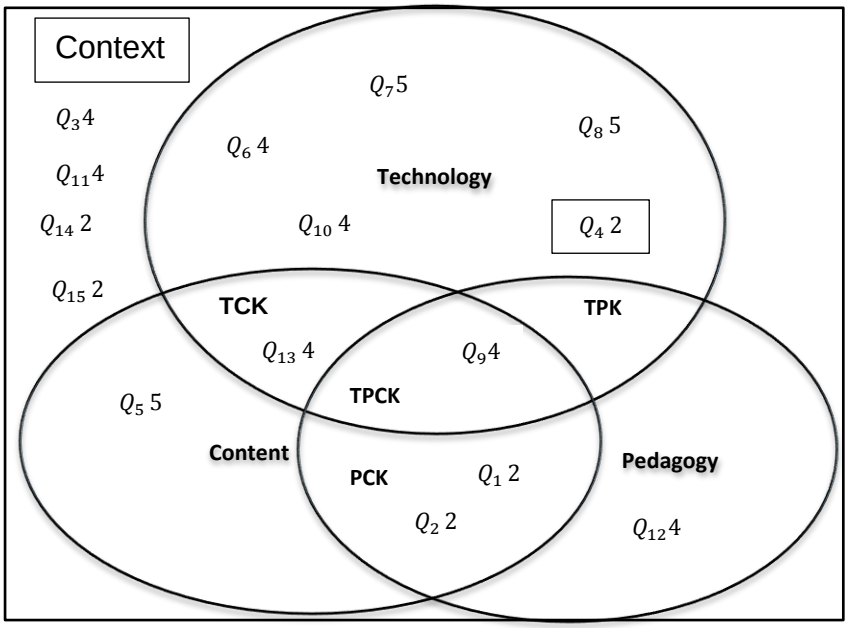
TPACK: Q9 – Good.

- She rated herself ‘good’ when coming to ICT integrating, the researcher agrees with her from lesson observation. It is very important for teachers to have skills to integrate ICT, refer to sub-section 2.7 in chapter 2.

Context: Q3 and 11 - Good; Q15 – Moderate; Q14 – Fair.

- She views context as good.

The following figure 4.2 represents the results of interview questions of teacher B in case A.



Questions	Ratings				
	1	2	3	4	5
1		√			
2		√			
3				√	
4		√			
5		√			
6				√	
7					√
8					√
9				√	
10				√	
11				√	
12				√	
13				√	
14		√			
15		√			

Figure 4. 2: Case A teacher B interview

The results of teacher B are as follows:

TK: Q4 – Fair, Q7 and 8 - Excellent; Q6 and 10 – Good.

- Teacher B is in the school where there is support, which is the reason why his technology knowledge is good. As per discussion under sub-section 2.1.2.1 in chapter 2, teachers need development to acquire more skills and knowledge on ICT resources.

PK: Q12 - Good.

- The pedagogy knowledge of teacher A is on moderate because he has only started ICT integration three years ago. More support is needed on his pedagogy knowledge.

CK: Q5 - Excellent.

- Teacher B knows the content very well.

TCK: Q13 - Good.

- Teacher B is good when using technology to teach the content.

PCK: Q1 and 2 – Fair.

- He needs more support on the methods of teaching using ICT.

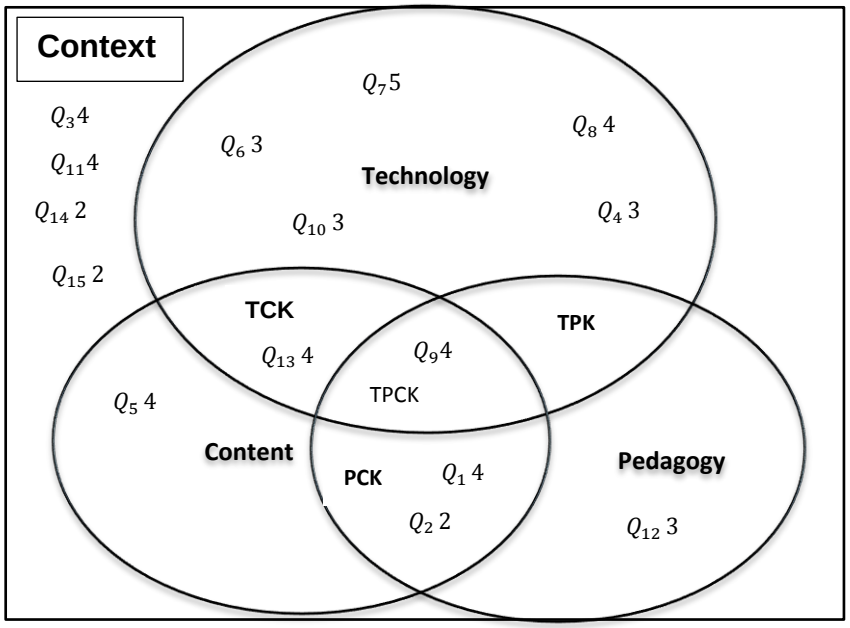
TPACK: Q9 – Good.

- He rated himself good when coming to ICT integrating, the researcher agrees with him from lesson observation.

Context: Q3 and 11 - Good; Q15 and 14 – Fair.

- He views context as fair. He thinks much work should be done by the school leadership to improve the ICT integration.

Figure 4.3 represents the results of interview questions of teacher A in case B.



Questions	Ratings				
	1	2	3	4	5
1				√	
2		√			
3				√	
4			√		
5				√	
6			√		
7					√
8				√	
9				√	
10			√		
11				√	
12			√		
13				√	
14		√			
15		√			

Figure 4. 3: Case B Teacher A interview

The results of teacher A are as follows:

TK: Q4 – Moderate; Q7 - Excellent; Q8 – Good; Q6 and 10 – Moderate.

- Teacher A is in the school where there is little support for ICT integration, but she has good technology knowledge according to herself. There is a vast need of teacher skills

development for to be equipped with knowledge and skills on ICT resources, refer to sub-section 2.5.2.1 in chapter 2

PK: Q12- Good.

- The pedagogy knowledge of teacher A is on 'good' because she has seventeen years of teaching experience.

CK: Q5 - Good.

- Teacher A knows the content.

TCK: Q13 - Good.

- Teacher A is good when using technology to teach the content.

PCK: Q1 and 2 – Fair.

- She needs more support on the methods of teaching.

TPACK: Q9 – Good.

- She rated her self-good when coming to ICT integrating, the researcher observed that ICT was used fairly during the lesson observation.

Context: Q3 and 11 - Good; Q14 and 15 – Fair.

- She views context as fair, more must be done by leadership to improve ICT integration

4.3.2. Lesson observation

The researcher observed the lessons with an aim of gaining insight and understanding of the occurrences without participating in the lesson, video recording was done. During the observations, the researcher made sure that there was no bias, but the lesson was observed holistically. The researcher used a video recorder and recorded the lesson to get more data in case of validity and reliability purposes. The researcher gathered the data without obstructing by observing the lessons that took place. The observation sheet is attached as Appendix J.

Checking of supporting documents

The researcher checked a few documents in each school before observation. The documents that were checked were a policy on ICT, lesson plans, workbooks and worksheets for learners that will be only sampled for focus group interview.

- **Policy on ICT**

The policy on ICT allows every stakeholder to be involved in the integration of ICT in the school. The policy is in line with the policy guideline on ICT that was given to all the schools by the DoE. The policy is clear and user-friendly.

- **Lesson Plans**

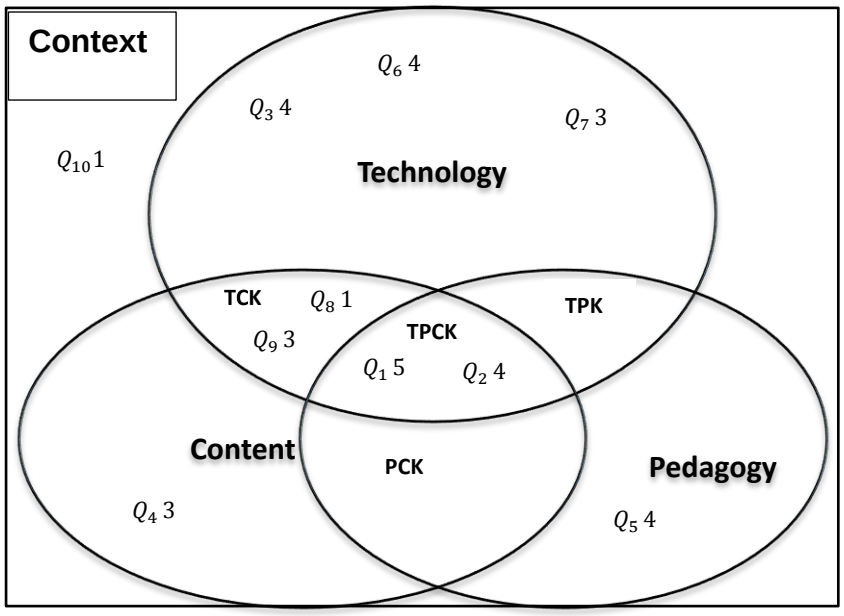
The researcher could go through their lesson plans that were done for the day of the lesson that was presented. The lesson plan was in line with annual teaching plans of the year 2017.

All the activities that were done during the lessons were stipulated in the daily lesson plans.

- **Learners' books and worksheets**

Seven learners from each school were randomly sampled from the classes by the researcher. Only learners with signed consent forms were considered during the sample. Those learners were learners who formed a group for focus group interviews. The researcher went through their books and worksheet. The work of learners was in order according to the annual teaching plan and the lesson that was prepared. Learners write in their workbooks but sometimes they are given assignments to do in their workbooks. They cannot submit answers, but they can only send to someone else with tablets.

Figure 4.4 represents the results of the lesson observation of teacher A in case A.



Questions	Ratings				
	1	2	3	4	5
1					√
2				√	
3				√	
4			√		
5				√	
6				√	
7			√		
8	√				
9				√	
10	√				

Figure 4. 4: Case A teacher A and learners' observation

The results of teacher A are as follows:

TK: Q3 and 6 - Good; Q7 – Moderate.

- Teacher A was good when coming to the integration of ICT in teaching Science.

PK: Q5 - Good.

- The pedagogy knowledge of teacher A was good. Even though much could have been done in terms of methods of teaching.

CK: Q4 - Good.

- Teacher A presented the lesson very well. Objections of the lesson were clear that showed that the teacher knew the content very well.

TCK: Q9 – Moderate; Q8 - Poor.

- Teacher A is excellent when using technology to teach the content.

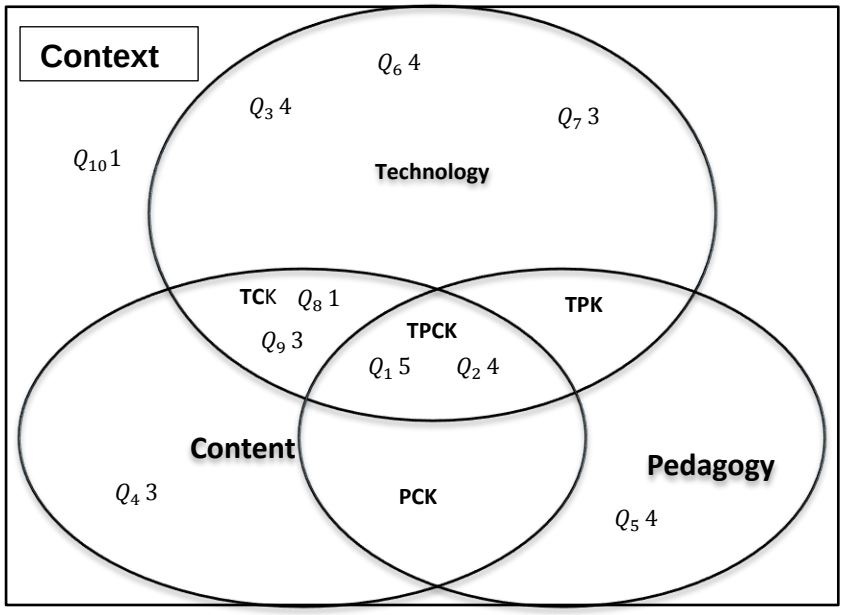
TPACK: Q1 – Excellent; Q2 – Good.

- She was very good in integrating ICT in teaching and learning.

Context: Q10 – Poor.

- The context of the class was poor. Learners were not using the tablets because of the poor WI-FI connection according to the teacher. Few learners could use the smartboard.

Figure 4.5 represents the results of lesson observation of teacher B in case A.



Questions	Ratings				
	1	2	3	4	5
1					√
2				√	
3				√	
4			√		
5				√	
6				√	
7			√		
8	√				
9			√		
10	√				

Figure 4. 5: Case A Teacher B and learners' observation

TK: Q3 and 6 - Good; Q7 – Moderate.

- Teacher B was good when coming to the integration of ICT in teaching Science.

PK: Q5 - Good.

- The pedagogy knowledge of teacher B was good. More could have been done to improve the method of teaching.

CK: Q4 - Good.

- Teacher B knows the content very well. He was presenting the lesson clearly. Learners were concentrating during his teaching. According to (Hogarth et al., 2006) ICT simulation in the teaching of Science to enhance higher thinking learning in the classroom, refer under sub-section 2.6.1 in chapter 2

TCK: Q9 – Moderate; Q8 - Poor.

- Teacher A is moderate when using technology to teach the content. The researcher observed that he needed the technician's help sometimes.

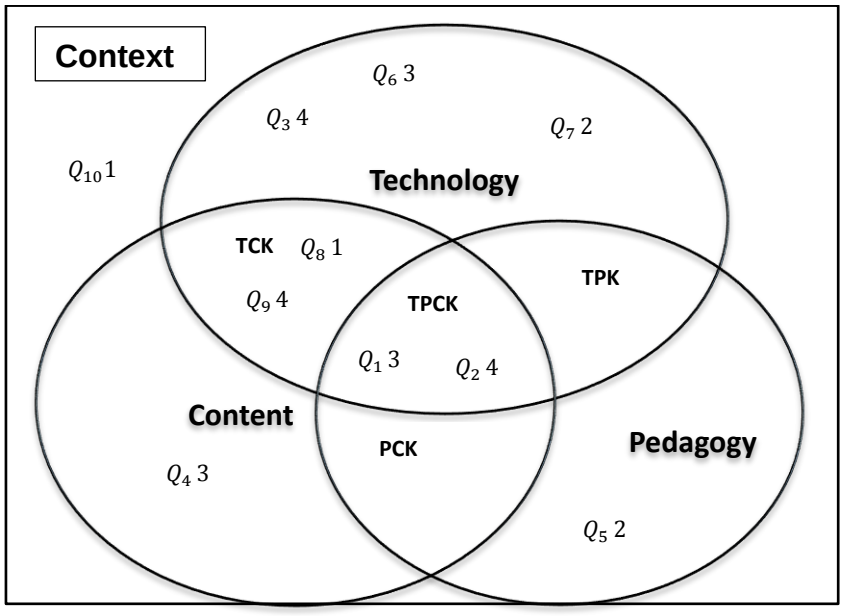
TPACK: Q1 – Excellent; Q2 – Good.

- He was moderate.

Context: Q10 – Poor.

- The context of the class was poor. Learners were not using the tablets because of the poor WI-FI connection according to the teacher. Few learners could use the smartboard.

Figure 4.6 represents the results of lesson observation of teacher B in case A.



Questions	Ratings				
	1	2	3	4	5
1			√		
2				√	
3				√	
4			√		
5		√			
6			√		
7		√			
8	√				
9				√	
10	√				

Figure 4. 6: Case B Teacher A and learners' observation

TK: Q3 and 6 - Good; Q7 – Moderate.

- Teacher A was moderate on the integration of ICT herself.

PK: Q5 - Good.

- The pedagogy knowledge of teacher A was good. Teacher A is well experienced in teaching Science.

CK: Q4 - Good.

- Teacher A knows the content very well. Teacher A has 17 years' experience teaching Science.

TCK: Q9 – Moderate; Q8 - Poor.

- Teacher A is having some difficulties to integrate technology to teach the Science. Most of the time she used a whiteboard marker to write on the board since the smartboard was given her a tough time
- TPACK: Q1 – Excellent; Q2 – Good.
- She was fair.

Context: Q10 – Poor.

- The context of the class was poor. Learners were not using the tablets because of the poor WI-FI connection according to the teacher. Few learners could use the smartboard. According to Lawless & Pellegrino 2007 not every teacher is using the technology in teaching and learning.

4.3.3. Teachers' questionnaire

Three teachers answered the questionnaires, two teachers in case A and one teacher from case B. The questions of the questionnaire are reflected in Appendix J.

Figure 4.10 represents the results of a questionnaire of teacher A in case A:

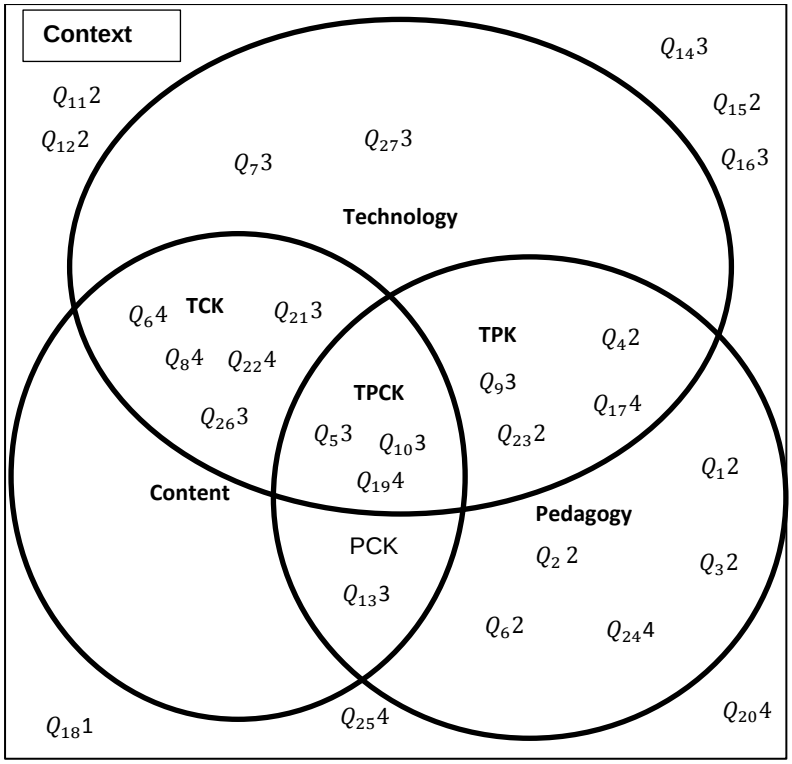


Figure 4. 7 : Case A Teacher A questionnaire

Questions	Ratings				
	1	2	3	4	5
1		√			
2		√			
3		√			
4		√			
5			√		
6		√			
7			√		
8				√	
9			√		
10			√		
11				√	
12		√			
13		√			
14					
15		√			
16			√		
17				√	
18	√				
19				√	
20				√	
21		√			
22				√	
23		√			
24				√	
25				√	
26			√		
27			√		

TK: Q7 and 27 – Moderate.

- Teacher A is in the school where there is support of ICT integration, she has good technology knowledge according to herself.

PK: Q24 – Good; Q1, 2, 3 and 6 Fair.

- The pedagogy knowledge of teacher A is on ‘good’ because she has three years of teaching experience teaching the same subject.

TPK: Q24 – Good; Q9 – Moderate; Q4 and 23 – Fair.

- Teacher A struggles a bit in teaching methods where ICT is integrated. She needs more support in terms of training.

TCK: Q6 and 22 – Good; Q8 – Moderate; Q21 and 26 - Fair.

- Teacher A is excellent when using technology to teach the content.

PCK: Q13 – Good.

- She needs more support on the methods of teaching.

TPACK: Q19 – Good; Q5 and 10 – Moderate;

- She rated herself moderate when coming to ICT integrating, the researcher agrees with her from lesson observation.

Context: Q20 and 25 – Good; Q14 and 16 – Moderate; Q11, 12 and 15 - Fair; Q18 - Poor.

- She views context as fair, more must be done by leadership to improve ICT integration.

The following figure 4.11 represents the results of a questionnaire of teacher B in case A.

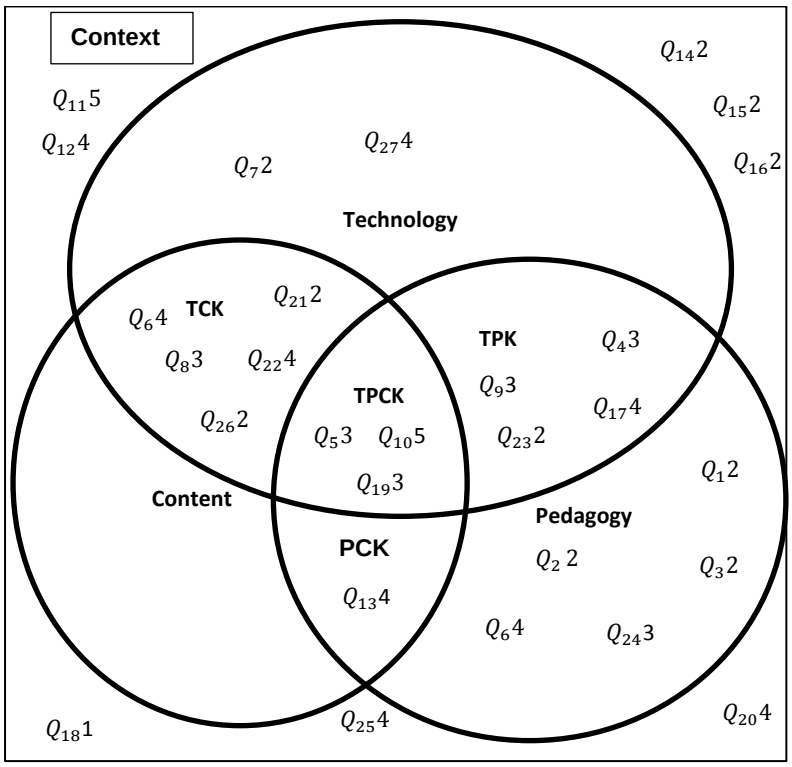


Figure 4. 8: Case A Teacher B questionnaire

Questions	Ratings				
	1	2	3	4	5
1		√			
2		√			
3		√			
4			√		
5			√		
6				√	
7		√			
8			√		
9			√		
10					√
11					√
12				√	
13				√	
14		√			
15		√			
16		√			
17				√	
18	√				
19			√		
20				√	
21		√			
22				√	
23		√			
24			√		
25				√	
26		√			
27				√	

TK: Q7 and 27 – Moderate.

- Teacher B is in the school where there is support of ICT integration. He has good technology knowledge according to herself.

PK: Q24 – Good; Q1, 2, 3 and 6 Fair.

- The pedagogy knowledge of teacher B is on ‘good’ because he has three years of teaching experience. He has been teaching Science.

TPK: Q24 – Good; Q9 – Moderate; Q4 and 23 – Fair.

- Teacher B struggles a bit in teaching methods where ICT is integrated. He needs more support in terms of training.

TCK: Q6 and 22 – Good; Q8 – Moderate; Q21 and 26 - Fair.

- Teacher B is good when using technology to teach the content.

PCK: Q13 – Good.

- He needs more support on the methods of teaching.

TPACK: Q19 – Good; Q5 and 10 – Moderate;

- He rated himself moderate when coming to ICT integrating, the researcher agrees with him from lesson observation.

Context: Q20 and 25 – Good; Q14 and 16 – Moderate; Q11, 12 and 15 - Fair; Q18 - Poor.

- He views context as fair, more must be done by leadership to improve ICT integration. More training on the use of technology is needed on the side of both teachers and learners.

The following figure 4.12 represents the results of a questionnaire of teacher A in case B

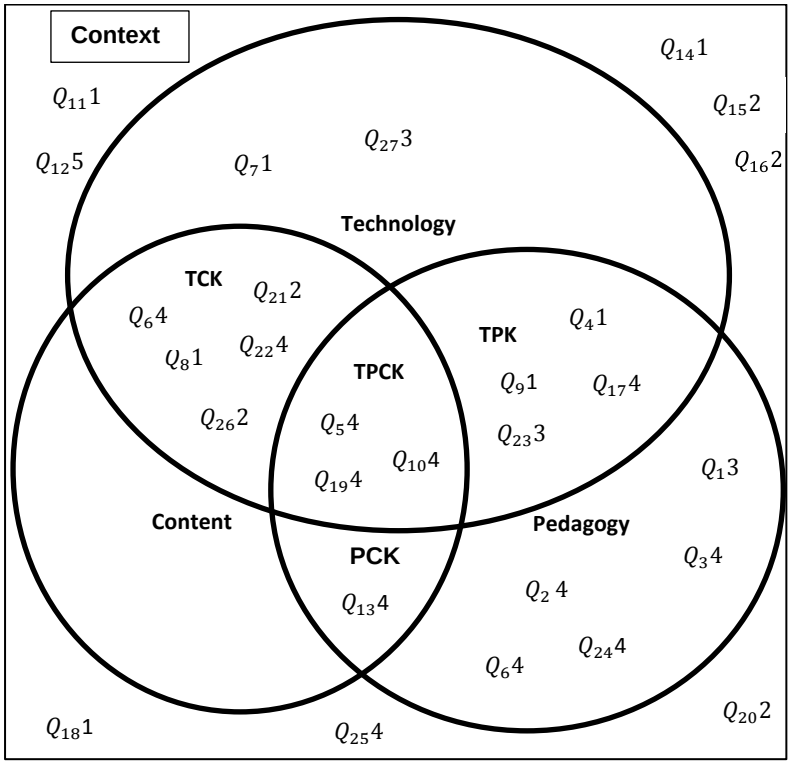


Figure 4. 9 : Case B Teacher A questionnaire

Questions	Ratings				
	1	2	3	4	5
1		√	√		
2		√		√	
3		√		√	
4	√				
5				√	
6				√	
7	√				
8	√				
9	√				
10				√	
11	√				
12					√
13				√	
14	√				
15		√			
16		√			
17				√	
18	√				
19				√	
20		√			
21		√			
22				√	
23			√		
24				√	
25				√	
26		√			
27			√		

TK: Q7 and 27 – Moderate.

- Teacher A is in the school where there is little support for ICT integration, but she has moderate technology knowledge according to herself.

PK: Q24 – Good; Q1, 2, 3 and 6 Fair.

- The pedagogy knowledge of teacher A is on good because she has seventeen years of teaching experience.

TPK: Q24 – Good; Q9 – Moderate; Q4 and 23 – Fair.

- She is on ‘moderate’. There is much training and support that is needed on the side of a teacher on how to dependently use ICT.

TCK: Q6 and 22 – Good; Q8 – Moderate; Q21 and 26 - Fair.

- Teacher A is moderate when using technology to teach the content.

PCK: Q13 – Good.

- She is good in the methods of teaching.

TPACK: Q19 – Good; Q5 and 10 – Moderate;

- She rated her self-good when coming to ICT integrating, the researcher observed that she needs more training on the use of ICT.

Context: Q20 and 25 – Good; Q14 and 16 – Moderate; Q11, 12 and 15 - Fair; Q18 - Poor.

- She viewed context as fair, she needs more training and if possible, even learners need to be trained on the use of tablets.

4.3.4. Results of learners' focus group interviews

The learners were interviewed in focus groups after the lessons. During the interview, the researcher audio recorded the interviews to obtain data for validity and reliability purposes. Focus group interviews were done using interview questions, as reflected in in Appendix K. Seven learners from each case took part in the focus group interview.

Figure 4.13 represents the results of focus group interviews with learners in case A.

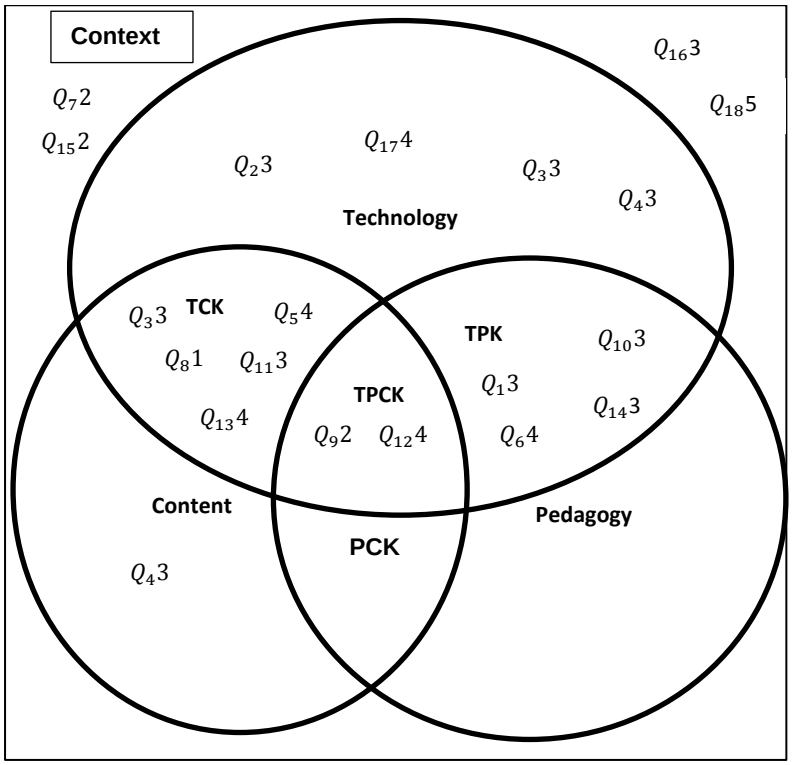


Figure 4. 10: Case A learners' focus group interview

Questions	Ratings				
	1	2	3	4	5
1			√		
2			√		
3			√		
4			√		
5				√	
6				√	
7		√			
8	√				
9		√			
10			√		
11			√		
12				√	
13				√	
14			√		
15		√			
16			√		
17				√	
18					√

The results of learners' focus group interview for case A are as follows:

TK: Q17 - Good; Q2, 3 and 4 – Moderate.

- Learners' technological knowledge is good according to them.

PK: No question.

- Learners were not questioned on pedagogical knowledge of their teachers.

CK: Q4 - Moderate.

- Learners' content knowledge through ICT integration is moderate because of the problems they encounter during the use of ICT.

TCK: Q13 - Good; Q3 and 5 – Moderate; Q11 – Fair.

- Moderate because of the problems to be addressed

PCK: No question.

- Learners were not questioned on pedagogical content knowledge of their teachers

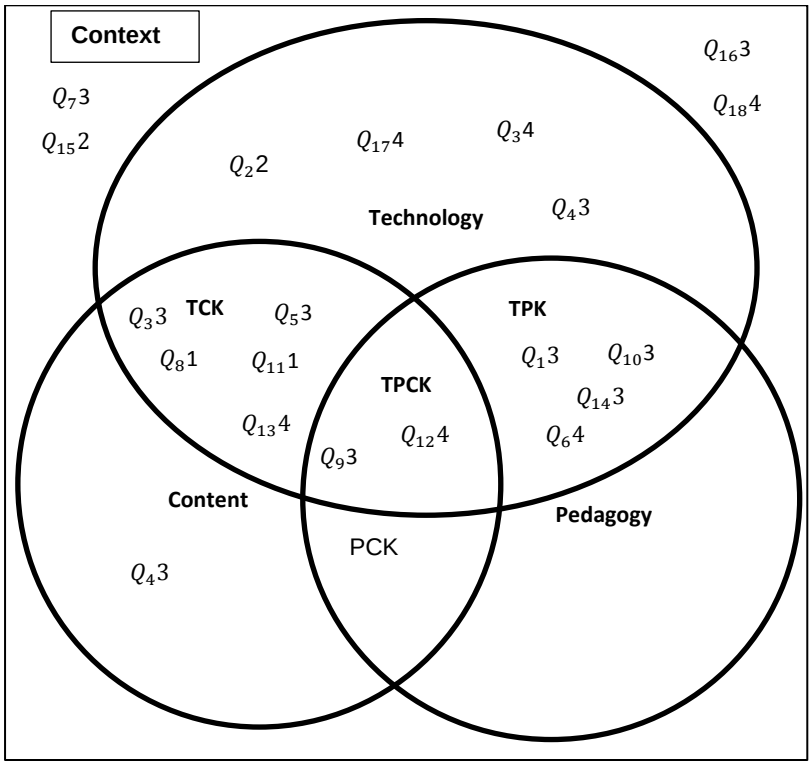
TPACK: Q12 – Good; Q9 - Fair.

- Much work needs to be done on ICT integration in teaching and learning according to the learner's point of view.

Context: Q18 – Excellent; Q16 - Moderate; Q7 and 15 – Fair.

- Context is good. According to (Hogarth, Bennett, Lubben, Campbell, & Robinson, 2006) learners' use of ICT simulations helped improve their understanding of science ideas significantly, refer to sub-section 2.4 in chapter 2.

Figure 4.14 represents the results of focus group interviews with learners in case B.



Questions	Ratings				
	1	2	3	4	5
1			√		
2		√			
3			√		
4			√		
5			√		
6				√	
7				√	
8	√				
9			√		
10			√		
11	√				
12				√	
13				√	
14			√		
15		√			
16			√		
17				√	
18				√	

Figure 4. 11: Case B learners' focus group interviews

The results of learners' focus group interview for case B are as follows:

TK: Q17 - Good; Q2, 3 and 4 – Moderate.

- Learners viewed their technology knowledge as moderate.

PK: No question.

- Learners were not questioned on pedagogical knowledge of their teachers.
- CK: Q4 - Moderate.
- Learners' content knowledge through ICT integration is moderate because of the problems they encounter during the use of ICT.

TCK: Q13 - Good; Q3 and 5 – Moderate; Q11 – Fair.

- Moderate because of the issues to be addressed according to learners.

PCK: No question.

- Learners were not questioned on pedagogical content knowledge of their teachers

TPACK: Q12 – Good; Q9 - Fair.

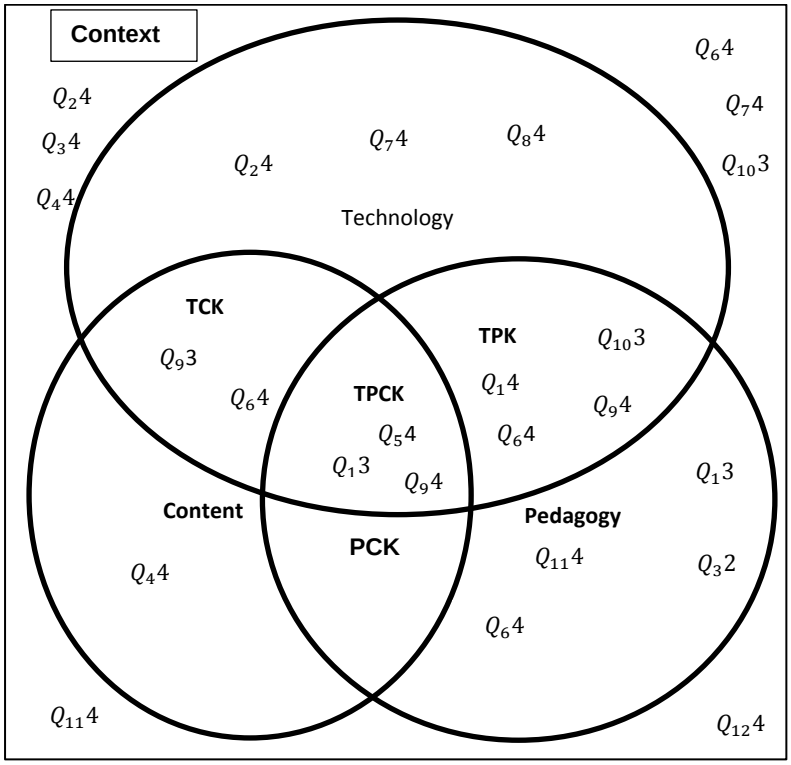
- Much work needs to be done in ICT integration in teaching and learning according to the learner's point of view

Context: Q18 – Excellent; Q16 - Moderate; Q7 and 15 – Fair.

- Context is good according to learners.

4.3.5. Results of ICT coordinators questionnaires

Two ICT coordinators answered questionnaires, the ICT coordinator from case A and B. The questions for ICT coordinators are reflected in Appendix M. Figure 4.15 represents the results of the questionnaire for the ICT coordinator in case A.



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

Figure 4. 12: Case A ICT coordinator's questionnaire

The results of the ICT co-ordinator case A questionnaire are as follows:

TK: Q2, 7 and 8 – Good.

- The coordinator viewed the technological knowledge of teachers as good.

PK: Q6 and 11 – Good; Q1 – Moderate; Q3 – Fair.

- She rated the pedagogical knowledge of teachers as good.

CK: Q4 - Good.

- She rated content knowledge as good.

TCK: Q6 - Good; Q9 – Moderate.

- Technological content knowledge was rated good.

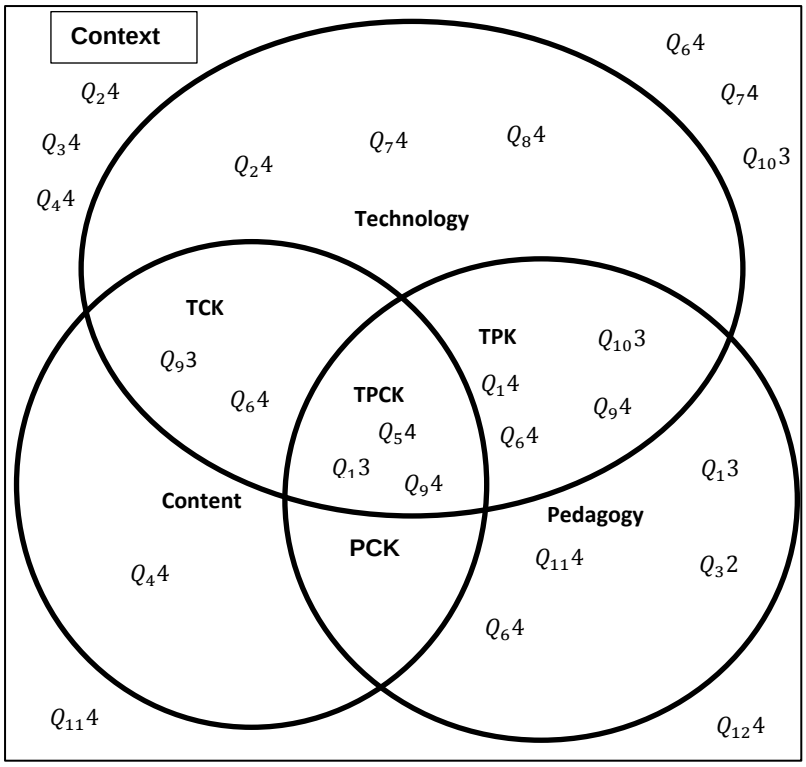
TPACK: Q5 and 9 – Good; Q1 - Fair.

- TPACK was rated as moderate since she believed more work should be done to improve ICT integration in their school.

Context: Q2, 3, 4, 6, 7, 11 and 12 – Good; Q10 - Moderate.

- She rated context good.

The following figure 4.16 represents the results of the questionnaire for the ICT coordinator in case B.



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

Figure 4. 13: Case B ICT coordinator's questionnaire

The results of the questionnaire for ICT co-ordinator in case B are as follows:

TK: Q2, 7 and 8 - Good.

- The coordinator rated the technology knowledge of teachers as good.

PK: Q6 and 11 – Good; Q1 – Moderate; Q3 – Fair.

- He rated pedagogical knowledge as moderate

CK: Q4 - Good.

- He rated content knowledge as good. The educator had been teaching Science for 17 years.

TCK: Q6 - Good; Q9 – Moderate.

- He rated technological knowledge as moderate. He stated that much work should be done by the leadership to develop teachers in the use of ICT.

TPACK: Q5 and 9 – Good; Q1 - Fair.

- He rated TPACK as moderate. A lot is expected from the leadership to develop teachers.

Context: Q2, 3, 4, 6, 7, 11 and 12 – Good; Q10 - Moderate.

- He rated context as moderate.

4.3.6. Principals' questionnaires

Two principals answered questionnaires. Principals from case A and B. The questions for principals are reflected in Appendix M.

The following figure 4.17 represents the results of the questionnaire for the principal in case A.

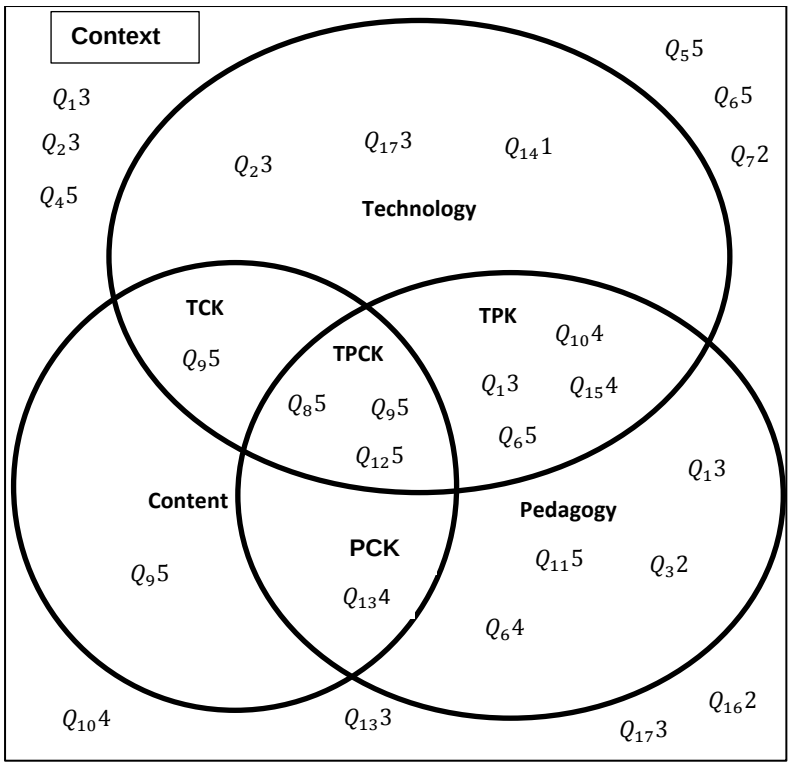


Figure 4. 14: Case A Principal's questionnaire

Questions	Ratings				
	1	2	3	4	5
1			√		
2			√		
3		√			
4					√
5					√
6					√
7		√			
8					√
9					√
10				√	
11					√
12					√
13				√	
14	√				
15				√	
16		√			
17			√		

TK: Q2 and 17 – Moderate; Q14 – Poor.

- The principal rated the technology knowledge of teachers as moderate

PK: Q11 – Excellent; Q6 - Good; Q3 – Fair; Q1 – Poor.

- He rated pedagogical knowledge good.

CK: Q9 - Excellent.

- He rated content knowledge excellent.

TCK: Q9 – Excellent.

- He rated technological content knowledge excellent.

PCK: Q13 – Good.

- He rated pedagogical knowledge good.

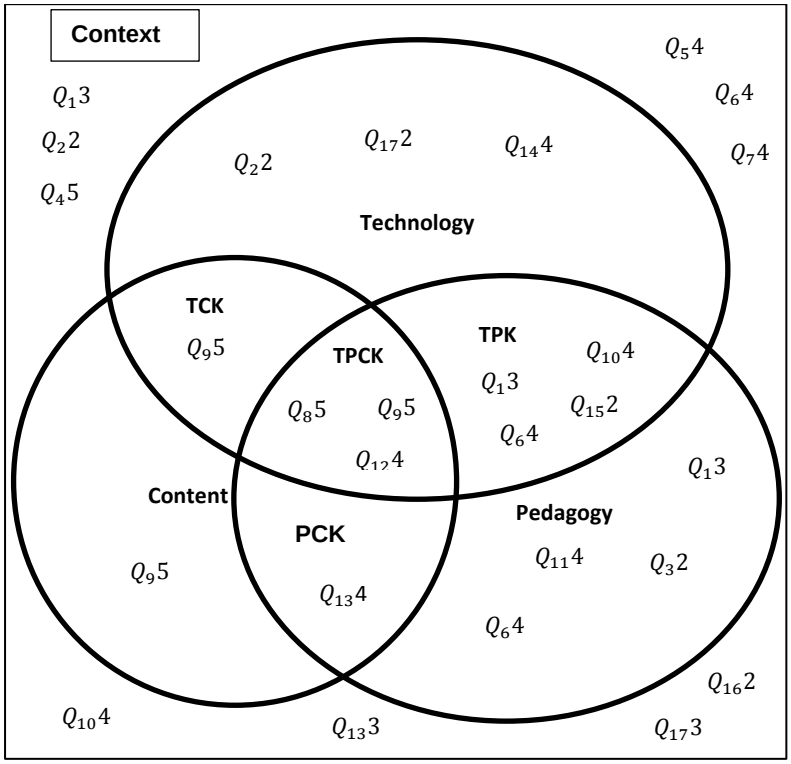
TPACK: Q8, 9 and 12 – Excellent.

- He rated TPACK excellent.

Context: Q4, 5 and 6 – Excellent; Q10 - Good; Q1, 2, 13 and 17 – Moderate; Q16 - Fair.

- According to the principal context is good.

Figure 4.18 represents the results of the questionnaire for the principal in case B.



Questions	Ratings				
	1	2	3	4	5
1			√		
2		√			
3		√			
4					√
5				√	
6				√	
7		√			
8					√
9					√
10				√	
11				√	
12				√	
13				√	
14		√			
15		√			
16		√			
17		√			

8

Figure 4. 15: Case B Principal's questionnaire

The results of the questionnaire for the Principal in Case B are as follows:

TK: Q2 and 17 – Moderate; Q14 – Poor.

- The principal rated technological knowledge fair.

PK: Q11 – Excellent; Q6 - Good; Q3 – Fair; Q1 – Poor.

- He rated pedagogical knowledge good.

CK: Q9 - Excellent.

- He rated content knowledge excellent. The teacher has 17 years of experience teaching Science.

TCK: Q9 – Excellent.

- He rated technological knowledge excellent.

PCK: Q13 – Good.

- He rated pedagogical content knowledge good.

TPACK: Q8, 9 and 12 – Excellent.

- He rated TPACK excellent.

Context: Q4, 5 and 6 – Excellent; Q10 - Good; Q1, 2, 13 and 17 – Moderate; Q16 - Fair.

- He rated context good.

4.4. Case descriptions

The case descriptions of this study are presented below and are based on the data analysis in Chapter 3, Section 3.6. Data analysis involves organizing the “raw or unprocessed answers from the interviews and field notes and developing themes and highlights found within them” (De Vos et al., 2014, p. 359). The case description from teachers’ interviews, lessons observations, learners' focus group interviews, teachers’ questionnaires, ICT coordinators’ questionnaire and principals’ questionnaires of case A and B are discussed below in the form of bar graphs.

The research instruments that were used are reflected in appendices H - N. This study was about finding out the Paperless classroom experiences in teaching and learning of Grade Seven Science learners in township schools. Previous studies on the use of technology in teaching and learning in some countries were considered.

The graphs in the following column represents the results from each participant. Case A is represented by the blue color. The researcher arranged the results according to

the participants in each case. Firstly, it would be the results for all data collecting instruments for teacher A and B in case A. It would be followed by the results of the context of case A.

4.4.1. Case A: teacher A

Figure 4.19 illustrates the results of interviews with teacher A.

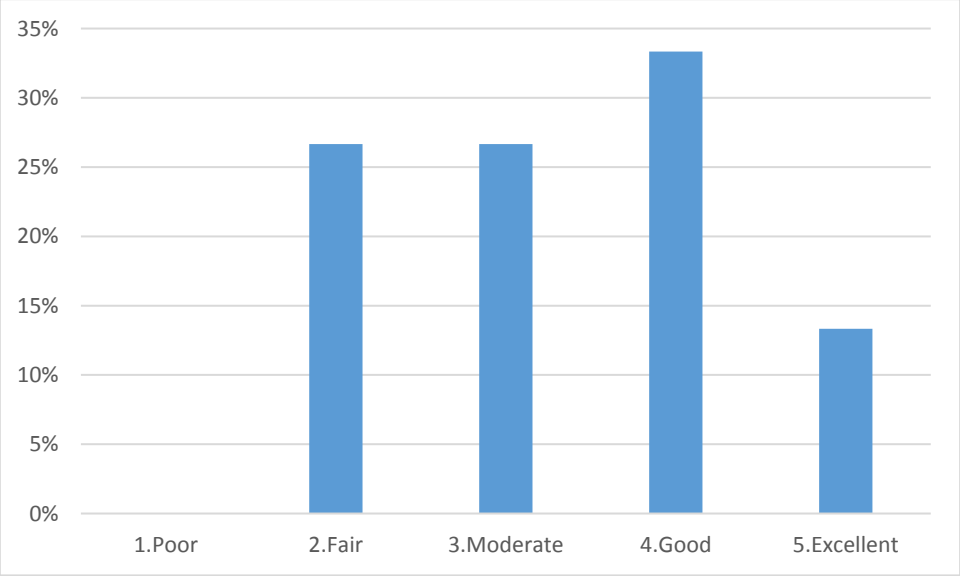


Figure 4. 16: Interviews

In Figure 4.19, ‘excellent’ was 13%, ‘good’ at 33%, ‘moderate’ at 27%, ‘fair’ at 27% and no ‘poor’ results for the ICT integration. It seems that teacher A is at a ‘moderate’ level in ICT integration according to the interview’s results. Learners are paying full attention according to the teacher, their focus is on what the teacher is doing on the smartboard. There is support from school management team as far as training in the use of ICT and support in terms of technicians. More can be done by the school to improve ICT integration.

Figure 4.20 illustrates the lesson observations for teacher A.

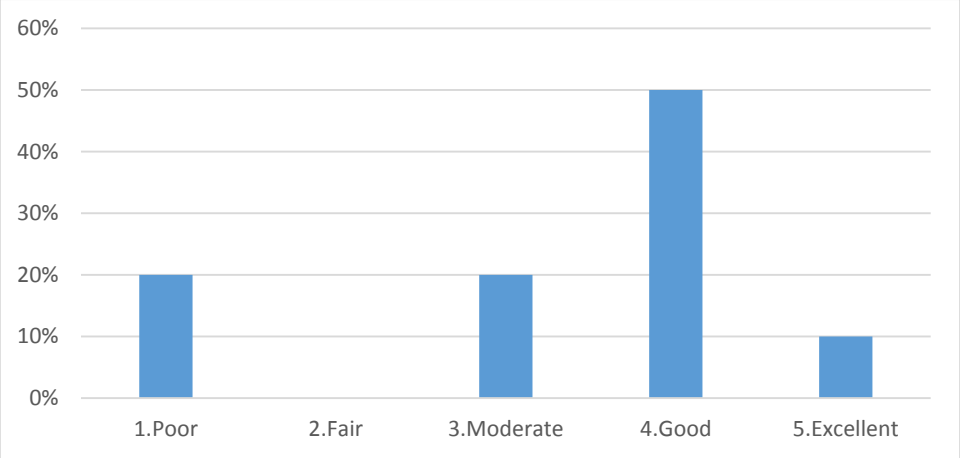


Figure 4. 17: Lesson observation

According to the way the lesson was observed, the lesson was rated ‘excellent’ was at 10%, ‘good’ at 50%, ‘moderate’ at 20% and ‘poor’ at 20%. The results of lesson observation by the researcher show that teacher A is good in ICT integration. The lesson was well introduced with the use of ICT resources in the class. Most of the ICT resources functioned reliably except that the WI-FI sometimes presented connectivity problems. Learners were not actively involved in using the resources effectively and creatively during the lesson because of the WI-FI connection. The teacher involved learners in using the smartboard when giving answers during the lesson. Learners were involved to do experiments on acids and bases.

Figure 4.21 illustrates questionnaire for teacher A

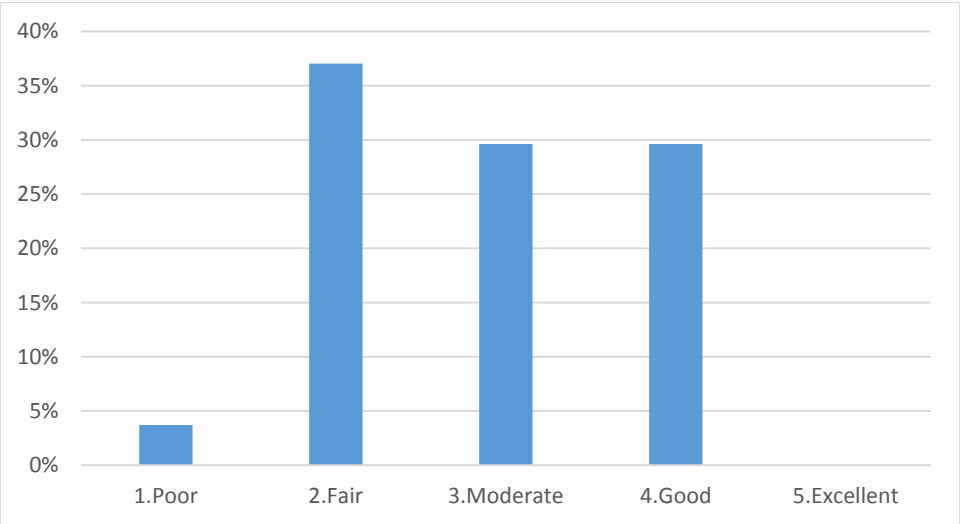


Figure 4. 18: Questionnaire

In Figure 4.21 no ‘excellent’ ratings were recorded, ‘good’ was at 30%, ‘moderate’ at 30%, ‘fair’ at 37% and ‘poor’ at 4%. According to the results of the questionnaire, teacher A is on ‘moderate’. She felt that much should be done from the side of the school management team and district office to make sure that the challenges towards ICT integration were addressed for better ICT integration in their school.

4.4.2. Case A: teacher B

Figure 4.7 illustrates interviews results for teacher B.

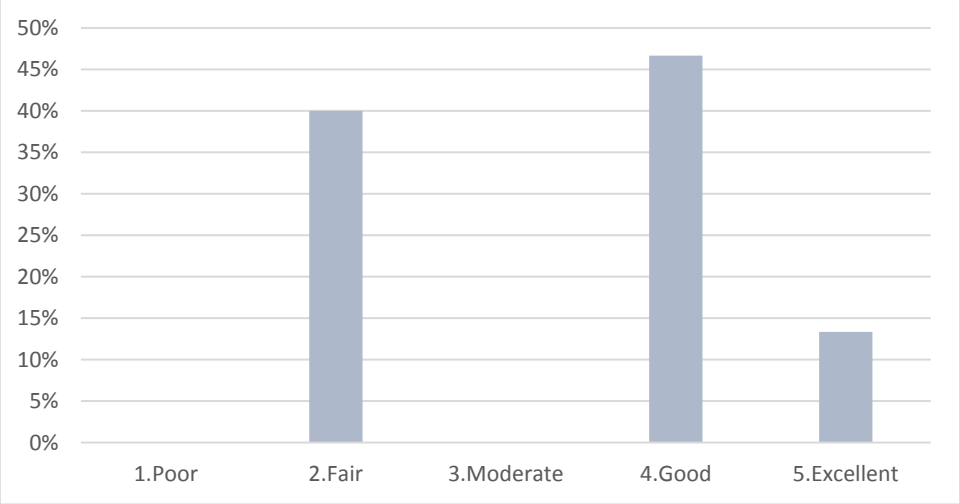


Figure 4. 19: Interviews

In Figure 4.7, teacher B got ‘excellent’ ratings at 13%, ‘good’ at 47%, ‘moderate’ at 0%, ‘fair’ at 40% and no poor results in the ICT integration. It seems that teacher B is at a moderate level in ICT integration according to the interview results. Learners were paying full attention according to the teacher, they were attracted to the videos and pictures appearing on the screen during the lesson. There was support from the school management team as far as training in the use of ICT and support in terms of technicians. More could be done by the school to improve ICT integration.

Figure 4.8 illustrates the findings of the lesson observations for teacher B.

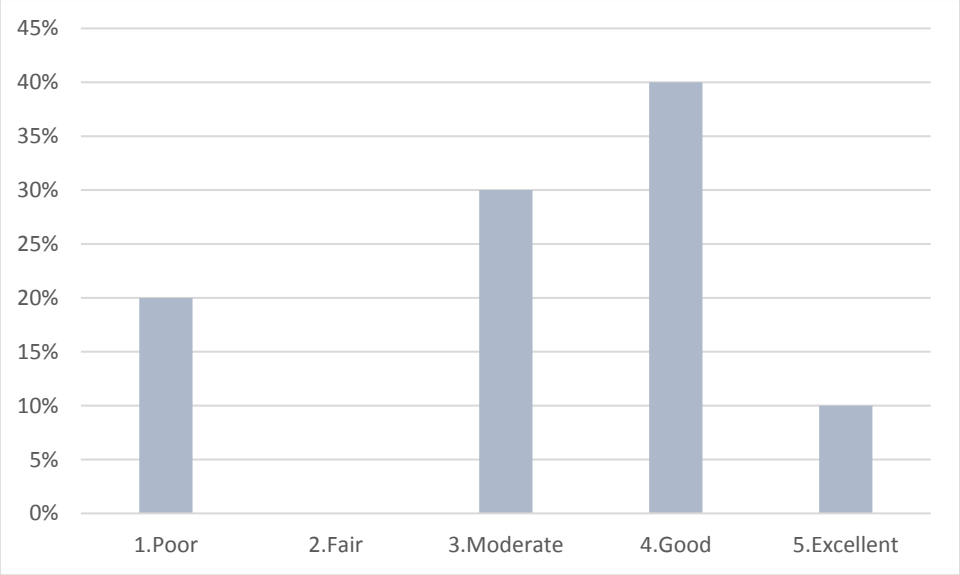


Figure 4. 20: Lesson observations

According to the way the lesson was observed, the lesson was rated as ‘excellent’ at 10%, ‘good’ at 40%, ‘moderate’ at 30%, no ‘fair’ results and ‘poor’ results at 20%. The results of lesson observation by the researcher show that teacher A is good in ICT integration. The lesson was well introduced with the use of ICT resources in the class. Most of the ICT resources functioned reliably except that the WI-FI sometimes presented connectivity problems. The WI-FI connection is the challenge to the whole school. Learners were not actively involved to use resources effectively and creatively during the lesson because of the WI-FI connection. There was noise at times. The class was overcrowded. The teacher did not involve learners to use the smartboard when giving answers during the lesson. Learners were involved practically when they were doing an experiment of mixing acids and bases.

Figure 4.9 illustrates the questionnaire results of teacher B.

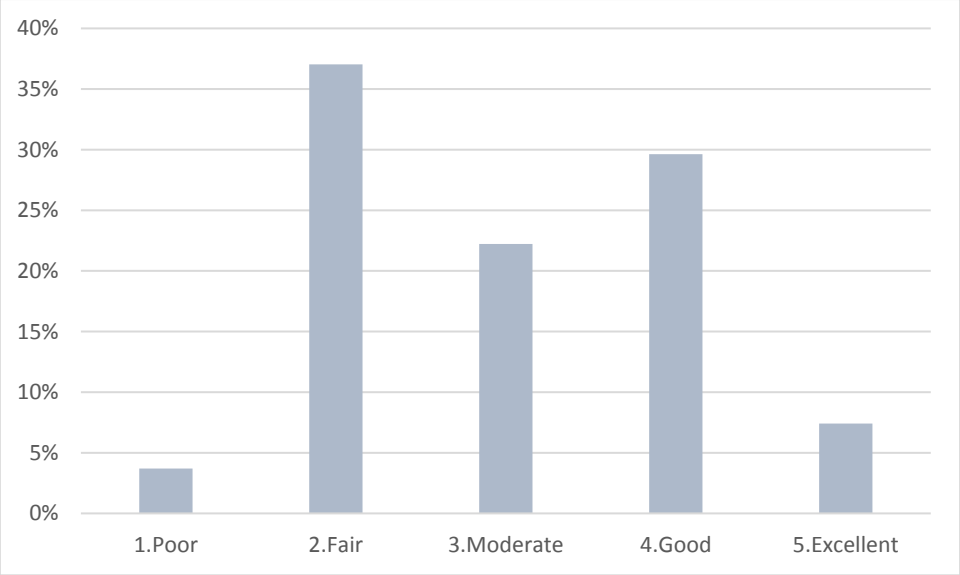


Figure 4. 21: Questionnaires

In Figure 4.9, teacher B got rated as ‘excellent’ at 7%, ‘good’ at 30%, ‘moderate’ at 27%, ‘fair’ at 37% and ‘poor; at 4%. According to the results of the questionnaire, teacher B is on moderate. He felt much should be done from the side of the school management team and district office to make sure that challenges towards the ICT integration were addressed for better ICT integration in their school.

4.4.3. Case A: context

Figure 4.22 illustrates the learners’ focus group results.

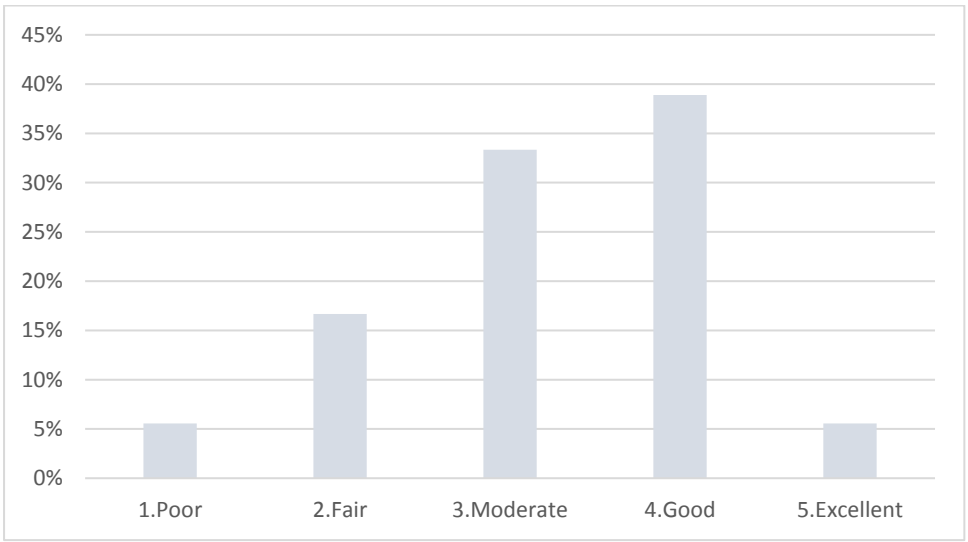


Figure 4. 22: Learner focus group Case A

In Figure 4.22, learners were rated at ‘excellent’ at 6%, ‘good’ at 39%, ‘moderate’ at 33%, ‘fair; at 17% and ‘poor’ at 6%. Learner attitudes towards ICT integration were good. Most learners agreed that ICT helps them to be innovative in the classroom as compared to the conventional teaching and learning. They alluded to the fact that they have a better chance of researching for themselves and finding information that is helpful in Science without the help of the teachers. Some learners are skillful in the use of ICT resources. There are challenges they come across during the use of ICT, like the WI-FI connection and the occasional electricity cut.

Figure 2.23 illustrates the results of the ICT co-ordinator’s questionnaire.

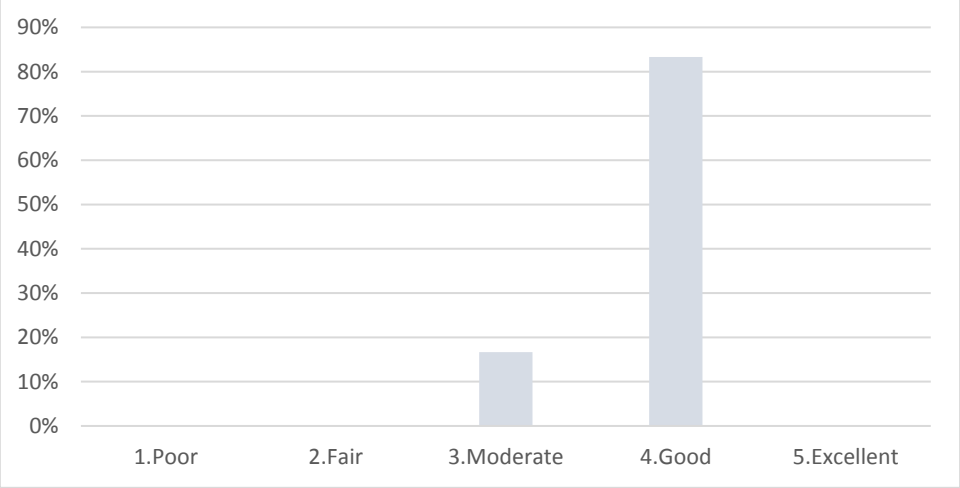


Figure 4. 23: ICT co-ordinator’s questionnaire Case A

In Figure 4.23, for the ICT co-ordinator no ‘excellent’ ratings, ‘good’ was rated at 83%, ‘moderate’ at 17%. There were no ‘fair’ or ‘poor’ ratings according to the results of the questionnaire. She rated the ICT integration at the school as good. There are clear ICT guideline policies from the DoE on how to implement technology in teaching. The leadership vision of the school encourages ICT integration in the school. The school management team supports the integration of ICT. Teachers were trained initially on how to integrate ICT in teaching and there is continuous training that is taking place, twice in a quarter. However, there are challenges which are big hindrances that need to be addressed concerning ICT integration in teaching and learning.

Figure 4.24 illustrates the results of the questionnaire for the principal.

Figure 4. 24: Principal's questionnaire Case A

In Figure 4.24, the principal got rated 'excellent' at 41%, 'good' at 18%, 'moderate' at 18%, 'fair' at 18% and 'poor' at 6%. The principal rated the ICT integration in the school as good. He alluded to the fact that the GDE vision encourages ICT integration. The school governing body and school management team are in full support of ICT integration in the school. There are clear ICT guideline policies for the implementation of ICT in schools that are helping the school to draft their own on the use of ICT. There are challenges that are being addressed in ICT integration.

The following column graphs represent the results from each participant. Case B is represented by the orange color. The researcher arranged the results according to the participants in each case. Firstly, it would be the results for all data collecting instruments for teacher A in case B. It would be followed by the results of the context of case B.

4.4.4. Case B: teacher A

Figure 2.25 illustrates interview results for teacher A.

Figure 4. 25: Interviews Case B

In Figure 4.25 above, teacher B was rated at ‘excellent’ at 7%, ‘good’ at 53%, ‘moderate’ at 20%, ‘fair’ at 20% while no ‘poor’ ratings were recorded in the results in the ICT integration. It seems that teacher B is at a good level in ICT integration according to interview results. Learners are paying full attention according to the teacher, they are attracted to the videos and pictures appearing on the screen during the lesson. There is no support from school management team as far as training in the use of ICT, but there is support in terms of technicians. Much needs to be done by the school to improve ICT integration.

Figure 4.26 illustrates the observations results for teacher A.

Figure 4. 26: Lesson observation Case B

According to the way the lesson was observed, the lesson had no 'excellent' ratings, 'good' was at 30%, 'moderate' at 30%, 'fair' at 20% and 'poor' at 20%. The results of lesson observations by the researcher show that teacher A is fair in ICT integration. The lesson was well introduced without much use of ICT resources in the class, during introduction only teacher's laptop was used. Most of the ICT resources did not function, the smartboard was not properly working, learners' tablets were not connecting and the WI-FI sometimes presented a connectivity problem. The WI-FI connection is the challenge to the whole school. Learners were not actively involved to use resources effectively and creatively during the lesson because of the WI-FI connection. Learners were well disciplined. The teacher did not involve learners to use the smartboard when giving answers during the lesson. Learners were involved practically when they were doing an experiment of mixing and separating different materials.

Figure 4.27 illustrates questionnaire results for teacher A.

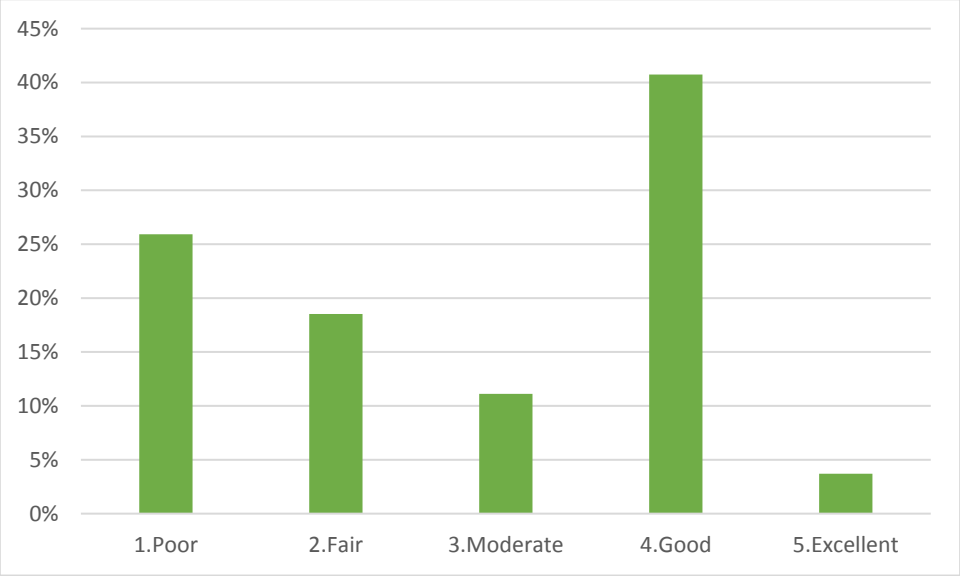


Figure 4. 27: Questionnaire Case B

In Figure 4.27,'excellent' was at 4%, 'good' at 41%, 'moderate' at 11%, 'fair' at 19% and 'poor' at 27%. According to the results of the questionnaire, teacher B is on fair. She felt that much should be done to support teachers in the ICT integration from the side of school management team and district office to make sure that the challenges towards ICT integration were addressed for better ICT integration in their school.

4.4.5. Case B: context

Figure 4.28 illustrates the learners' focus group results.

Figure 4. 28: Learners' focus group Case B

In Figure 4.28, learners received no 'excellent' ratings, 'good' was rated at 33%, 'moderate' at 50%, 'fair' at 6% and 'poor' at 11%. Learners' attitudes towards ICT integration were moderate. Most learners agreed that ICT helps them to be innovative in the classroom as compared to the conventional teaching and learning. They alluded to the fact that they had a better chance of researching for themselves and finding information that was helpful in Science without the help of the teachers. Some learners are skillful in the use of ICT resources. There are challenges they come across during the use of ICT, like the WI-FI connection and the occasional electricity cut. Most of the learners needed training on how to use ICT resources, they were struggling and most of the teachers did not support them because even teachers were failing to integrate ICT. Most of the teachers in the school were about to retire.

Figure 4.29 illustrates questionnaire results for the ICT co-ordinator.

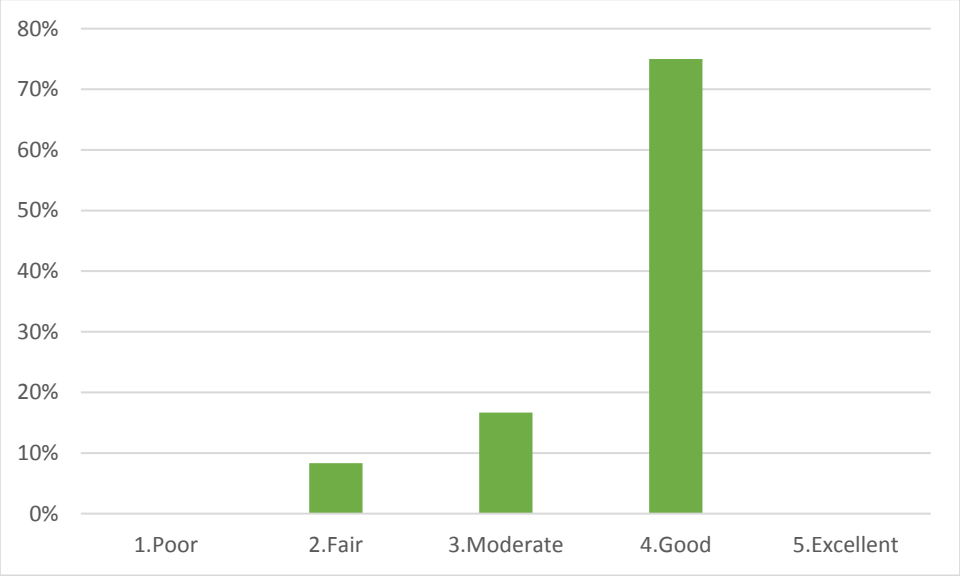


Figure 4. 29: ICT co-ordinator Case B

In Figure 4.29, the ICT co-ordinator received no 'excellent' ratings, 'good' was at 75%, 'moderate' at 17%, 'fair' at 8%, no 'poor' ratings were reported in the results of the questionnaire. He rated the ICT integration at the school as moderate. There are clear ICT guideline policies from the DBE on how to implement technology in teaching. The leadership vision of the school encourages ICT integration in the school, but the practical part of encouragement is lacking from the side of school management team in the integration of ICT. Teachers were trained initially on how to integrate ICT in teaching but there was no continuous training that was taking place. There are challenges which are big hindrances that need to be addressed concerning ICT integration in teaching and learning.

Figure 4.30 illustrates questionnaire results for the principal.

Figure 4. 30: Principal's questionnaire Case B

In Figure 4.30, the principal was rated 'excellent' at 18%, 'good' at 41%, 'moderate' at 6%, 'fair' at 35% while no 'poor' ratings were received. The principal rated the ICT integration in the school as moderate. He alluded to the fact that the GDE vision encourages ICT integration. The school governing body and school management team are in full support of ICT integration in the school. There are clear ICT guideline policies for implementation of ICT in the school that are helping the school to draft their own on the use of ICT. There are challenges that are being addressed on ICT integration. According to Mukhari (2014) South Africe is controlled with, amongst others, barriers to integration such as internal barriers, external barriers or factors influencing the use of ICT, refer to sub-section 2.6.2 in chapter 2.

4.5. Discussion of conclusions

The research results were presented in this chapter. The results were presented according to the data that was collected. The results include interviews of all the teachers, (refer to Section 4.3.1); lesson observations, (refer to Section 4.3.2); teachers' questionnaire results (refer to Section, 4.3.3); learners' focus groups, (refer to Section 4.3.4); ICT coordinators, (refer to Section 4.3.5) and the principals' questionnaires, (refer to Section 4.3.6). All the results were presented according to hermeneutics principles that were discussed in Section 3.6.2 of Chapter 3. The findings and conclusions are discussed next in Chapter 5.

Chapter 5	5.1 Introduction
	5.2 Summary of cases
	5.3 Research question revisited
	5.4 TPACK
	5.5 Exceptions
	5.6 Shortcomings and limitations
	5.7 Recommendations
	5.8 Benefits to the field of study
	5.9 Proposed new question
	5.10 Conclusion

5. Findings and conclusions

5.1. Findings

5.1.1. Introduction

In the previous chapter, the results were discussed. The researcher explained results from each instrument that was used during data collection. In this chapter findings per case are discussed and analysed data is was presented according to the different cases. In this study a description of two cases was done, refer to Section 3.3.3.1 of Chapter 3 for the descriptive case study. In case study research, “the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audio-visual material, and documents and reports) and reports a case description and case-based themes” (J. Creswell et al., 2007). The presentation of analysed data is based on Figure 5.1 that is the summative graph of case A and Figure 5.2 that is the summative graph of case B. During data analysis the important hermeneutics principles were considered, refer to Section 3.6.2 in Chapter 3. The following is the summary of the cases.

5.2. Summary of cases

5.2.1. Case A summary

The following Figure 5.1 illustrates the whole picture of Case A.

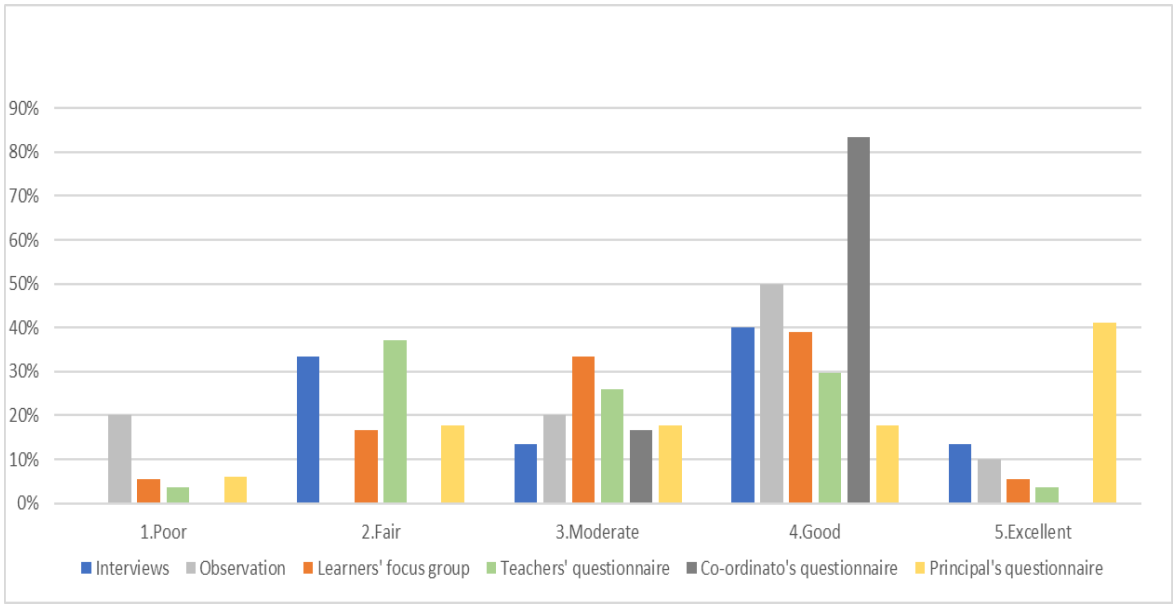


Figure 5. 1 Case A summative graph

The graph above indicates blue the results for teachers' interviews, light grey the results for lesson observation, orange the results for learners' focus group interviews, green the results for teachers' questionnaires, dark grey results for ICT co-ordinators' questionnaires and yellow results for principals' questionnaires. On each rating all the above colours might appear depending on the results. For an example, under rating 1 no results on teachers' interviews and ICT co-ordinators' questionnaires but results on lesson observation, learners' focus group interviews, teachers' questionnaires and principal's questionnaires. Also check rating 4 all colours are represented.

5.2.1.1. Teachers' interviews

In this study structured and recorded interviews were administered to teachers, refer to Section 3.5.1.1 of Chapter 3. According to the graph in Figure 5.1 regarding the interviews, the results ranged from fair to good. Educators are getting support in ICT integration from the school management team. They attended training on the use of

ICT. The case has two sponsors which are Vodacom and Matthew Goniwe. Vodacom ran training and workshops for all teachers in the school.

5.2.1.2. Lesson observation

The purpose of lesson observation, as explained in Chapter 3 under Section 3.5.1.2, was that the researcher aimed to observe what was certainly happening in the classroom. The researcher observed presentations of the natural science lessons with the ICT integration. The researcher videotaped the lesson presentation. The researcher focused on how learners were involved, how the attitudes of teachers and learners were towards ICT integration and what the challenges were that were faced by teachers and learners during ICT integration. Another major benefit of using ICT in science education is “that it expands the pedagogical horizons and resources available to science teachers” (Al-Alwani, 2005)

According to Figure 5.1 above, the lesson observation findings were good. Teachers presented the lessons well. Teachers used laptops and interactive boards. Initially teachers introduced the lessons using their laptops and interactive boards. When it was time for questions and answers learners could use interactive boards. Most of the learners could give answers by using the pictures that were on the interactive board. Most of the learners provided the correct answers. Teachers continued with their lessons but in both classes, there was a problem with WI-FI connection, somehow leaners’ tablets were taken away. Learners had their workbooks and wrote the class activity in their workbooks.

5.2.1.3. Teachers’ questionnaires

The purpose of teachers’ questionnaires that were administered was that the researcher aimed to get a broader understanding of the attitudes, challenges, and benefits of teachers at stake concerning the ICT integration Science teaching and learning, refer to sub-section 3.5.1. in Chapter 3.

According to Figure 5.1, the findings of the results for questionnaires ranged from fair to moderate. Teachers spotted many challenges that are hindering them in respect of smooth integration of ICT, refer to Section 4.3.3 for the results. Researchers indicate

that teachers' quality is negatively correlated with the learner's performance (Akinfe et al., 2012; Burns, 2012).

5.2.1.4. Learners' focus group

The researcher aimed to find out from the learners, which technological resources they used in the class during ICT integration in natural science, and to find out about the challenges and benefits of learners when ICT was integrated in Science teaching and learning, refer to Section 3.5.1.4 in Chapter 3.

According to Figure 5.1 above**,** findings ranged from moderate to good. Learners were given a chance to answer questions concerning the integration of ICT. Learners had positive attitudes towards the integration of ICT in teaching and learning natural science. Some benefitted a lot during the lesson, most could find information for themselves. They spotted challenges like problems in WI-FI connections and cuts in electricity that were giving them problems. They also highlighted the issue of some apps that other learners are accessing that are disturbing to them.

5.2.1.5. ICT co-ordinators' questionnaire

The aim of the researcher was to find out the view of the ICT co-ordinator concerning ICT integration in the school. The data gathered from the ICT co-ordinator helped the researcher to have more information on the context of the case.

According to the graph in Figure 5.1, findings were rated at 'good'. According to the ICT coordinator, ICT integration in the school was good. Teachers were getting support from the school management team even though a lot of work should be done by leadership to develop teachers to use ICT resources independently, currently they get support from a technician. She had a concern on issues that were causing challenges for them, like cuts of electricity and WI-FI connections. She alluded to the fact that most of the time teachers failed to use ICT resources because of the above challenges.

5.2.1.6. Principals' questionnaire

The aim of the researcher was to find out the view of principals concerning ICT integration in their school. The data gathered from the principals helped the researcher to have more information on the context of the cases.

According to graph in Figure 5.1, findings rated mostly as 'excellent'. The principal rated the technological knowledge of teachers as good. Teachers were integrating ICT well in the class. The context of the school was good.

The overall ICT integration in Science in case A was good, according to Figure 5.1 above. Considering the challenges that participants are encountering, much must be done by school leadership together with the Department of Education.

The following is summary of the results in case B.

5.2.2. Case B summary

Figure 5.2 illustrates the whole picture for Case B.

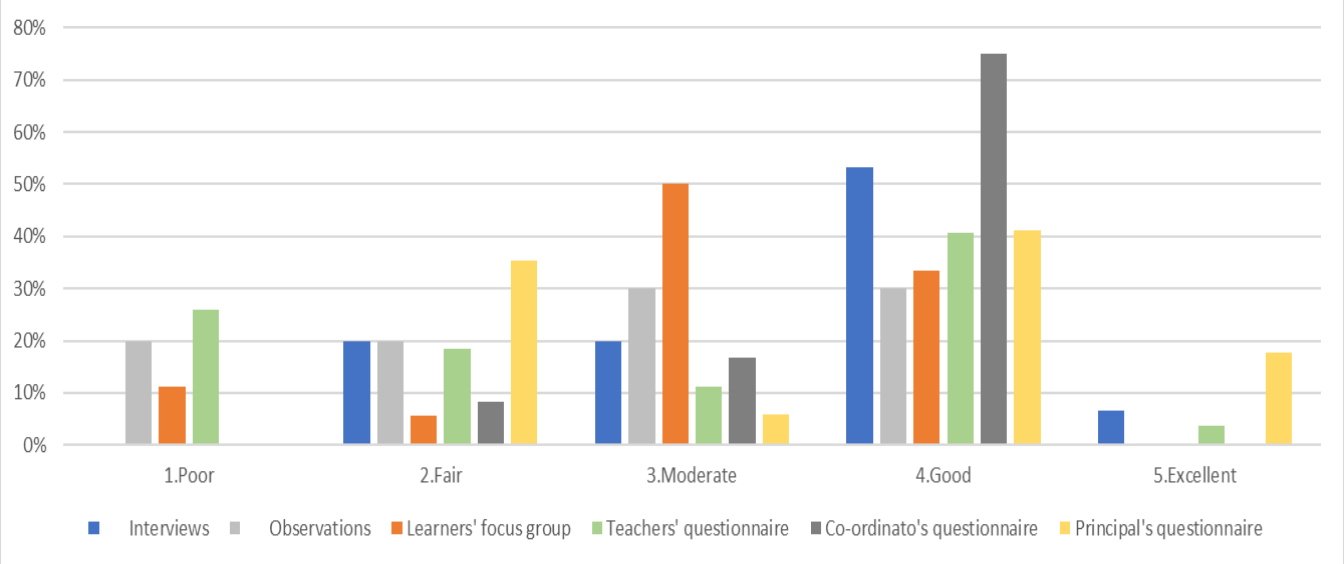


Figure 5. 2: Case B summative graph

The graph above indicates blue the results for teachers' interviews, light grey the results for lesson observation, orange the results for learners' focus group interviews, green the results for teachers' questionnaires, dark grey results for ICT

co-ordinators' questionnaires and yellow results for principals' questionnaires. On each rating all the above colours might appear depending on the results. For an example, under rating 1 no results on teachers' interviews, ICT co-ordinators' questionnaires and principal's questionnaire but results on lesson observation, learners' focus group interviews and teachers' questionnaires. Also check rating 4 all colours are represented.

5.2.2.1. Teachers' interviews

According to Figure 5.2, interview results rate mostly as good. Teachers received training on ICT integration from Matthew Goniwe. The teacher had challenges that should be attended to by school leadership.

5.2.2.2. Lesson observation

The researcher observed presentations of the natural science lessons with the ICT integration. The researcher videotaped the lesson presentations. The researcher focused on how learners were involved, how the attitudes of teachers and learners were towards ICT integration and what the challenges were that were faced by teachers and learners during ICT integration.

According to Figure 5.2 above, the lesson observation findings of the results ranged from 'moderate' to 'good'. The teacher introduced the lesson by starting with the questions and answers of the previous lesson. She later used her laptop and writing on the interactive board using a board marker. Much work needs to be done by the teacher to familiarise herself with ICT resources. The teacher sometimes struggled to use the interactive board, the technician was called now and then to support the teacher. Finally, there was a problem with the WI-FI connection so that the leaners could not use tablets. Learners had their workbooks and wrote the class activity in their workbooks.

5.2.2.3. Teachers' questionnaires

According to Figure 5.2 above, the findings of the results for questionnaires were clustered on 'good'. Teacher A complained of the little support for ICT integration on the side of school management. She needed more training on the use of ICT

resources. Teachers are intimidated by technology and are comfortable with their own teaching styles which involve face to face lecturing with learners having to memorize the contents (James et al., 2003).

She spotted many challenges that were hindering her in the smooth integration of ICT, refer to Section 4.3.3 for the results. Researchers indicate that teachers' quality is negatively correlated with the learners' performance (Akinfe et al., 2012; Burns, 2012).

5.2.2.4. Learners' focus group

According to Figure 5.2**,** the findings were clustered on 'good'. Learners were given a chance to answer questions concerning the integration of ICT. Learners had positive attitudes towards the integration of ICT in teaching and learning natural science. Some benefited a lot during the lesson, most could find information for themselves. They spotted challenges like problems in the WI-FI connection and cuts in electricity that was giving them a problem. They also highlighted the issue of some apps that other learners were accessing that were disturbing to them.

5.2.2.5. ICT co-ordinators' questionnaire

According to the graph in Figure 5.2, the findings rated at 'good'. According to the ICT coordinator, ICT integration in the school was good. Teachers were getting support from the school management team even though much work should be done by leadership to develop teachers to use ICT resources independently, currently they get support from a technician. He had a concern regarding issues giving them challenges like cuts of electricity and the WI-FI connection. He alluded to the fact that most of the time teacher failed to use ICT resources because of the above challenges.

5.2.2.6. Principals' questionnaire

According to the graph in Figure 5.2, findings rated mostly on 'good'. The principal rated the technological knowledge of teachers as good. Teachers were integrating ICT well in the class. The context of the school was good.

The overall ICT integration in Science in case B was 'moderate' to 'good'. Considering the challenges that participants were encountering, much must be done by school leadership together with the Department of Education.

5.3. Research questions revisited

5.3.1. Secondary question 1

How is ICT integration in Grade 7 Science classroom in the Paperless classroom project?

The results for the two cases differed somewhat and is discussed separately.

Case A

The integration was good. The school has a clear policy on how to integrate ICT in teaching and learning. The policy was generated from the GDE policy guideline on how to integrate ICT in teaching and learning. The teachers integrated ICT during their lessons which showed that they had skills on how to integrate ICT in Science. They used laptops and interactive boards to deliver their lesson. Teachers were at ease to integrate ICT during the lessons. It showed that school had full support from Matthew Goniwe where teachers are trained on how to integrate ICT during teaching and learning. The teachers are fully supported by the leadership in the integration of ICT. The technician supports teachers anytime they call for help.

Case B

The school integrated from ‘moderate’ to ‘good’. The school has a clear policy on how to integrate ICT in teaching and learning. The policy was generated from the GDE policy guideline on how to integrate ICT in teaching and learning. The teacher used a laptop and was starting to use interactive the board, she would sometimes use the board marker or the green board. The teacher had limited computer skills. There was no training to support the teachers. The technician had to help now and again.

5.3.2. Secondary question 2

Which challenges did the participants experience during implementation?

Both cases experienced similar challenges during ICT integration.

Case A and Case B

When WI-FI connection was down sometimes it gave the participants the challenge because they had to stop the lesson and try other means of teaching which was to use

a green board. The electricity cuts challenged the participant because all the ICT resources they were using needed electricity to function. The theft of tablets caused learners to leave tablets in schools and not use them at home. Learners who needed full supervision because they tended to watch videos that were not teaching them good lessons but derailing them.

5.3.3. Secondary question 3

How did the implementation benefit the teaching and learning processes?

Case A and Case B

The benefits in both schools were similar. The implementation of ICT in teaching and learning benefited most of the learners and teachers. The teachers in case A were trained by Matthew Goniwe and Vodacom. The teachers in case B were trained by Matthew Goniwe. Teachers who were computer illiterate were privileged to become computer literate because of the pilot project that was initiated by the GDE, refer to Section 3.3.3.2 of Chapter 3 for a description of the cases.

Learners were so excited that they could search for information they were looking for from the internet even during the absence of teachers. Learners also highlighted that because of the videos that could show them some processes for an example germination of a maize plant, they understood it easily when watching the video, refer to Appendix N – R where learners' responses are captured.

5.3.4. Primary question

What are the experiences of teachers and learners in Grade 7 Science in township schools in the Paperless project?

According to the findings, the experience of teachers and learners in the Paperless project is good even though there are challenges. Learners felt motivated by using technology while learning, refer to Section 2.7.3.2 of Chapter 2. Teachers and learners explained their insight concerning their experiences, benefits, and challenges with ICT integration, refer to Chapter 4 for the results. Teachers needed more training and support in integration. They viewed integration as good practice if the challenges they come

across could be attended to by the schools' leadership and the Gauteng Department of Education.

5.4. Revisiting the conceptual framework: TPACK

TPACK refers to "…a synthesized form knowledge for the purpose of integrating ICT/educational technology into classroom teaching and learning" (Koh et al., 2013). It is "…a framework for understanding the relationship between teachers' knowledge of technology, content knowledge, and knowledge about teaching" (Koh et al., 2013; Morsink et al., 2011), refer to Section 2.9 in Chapter 2. Figure 5.3 depicts TPACK that was used as a conceptual framework in this study. It was also used to categorise questions for the instruments of data collection, refer to Section 3.5.1 of Chapter 3 for a description of the instruments.

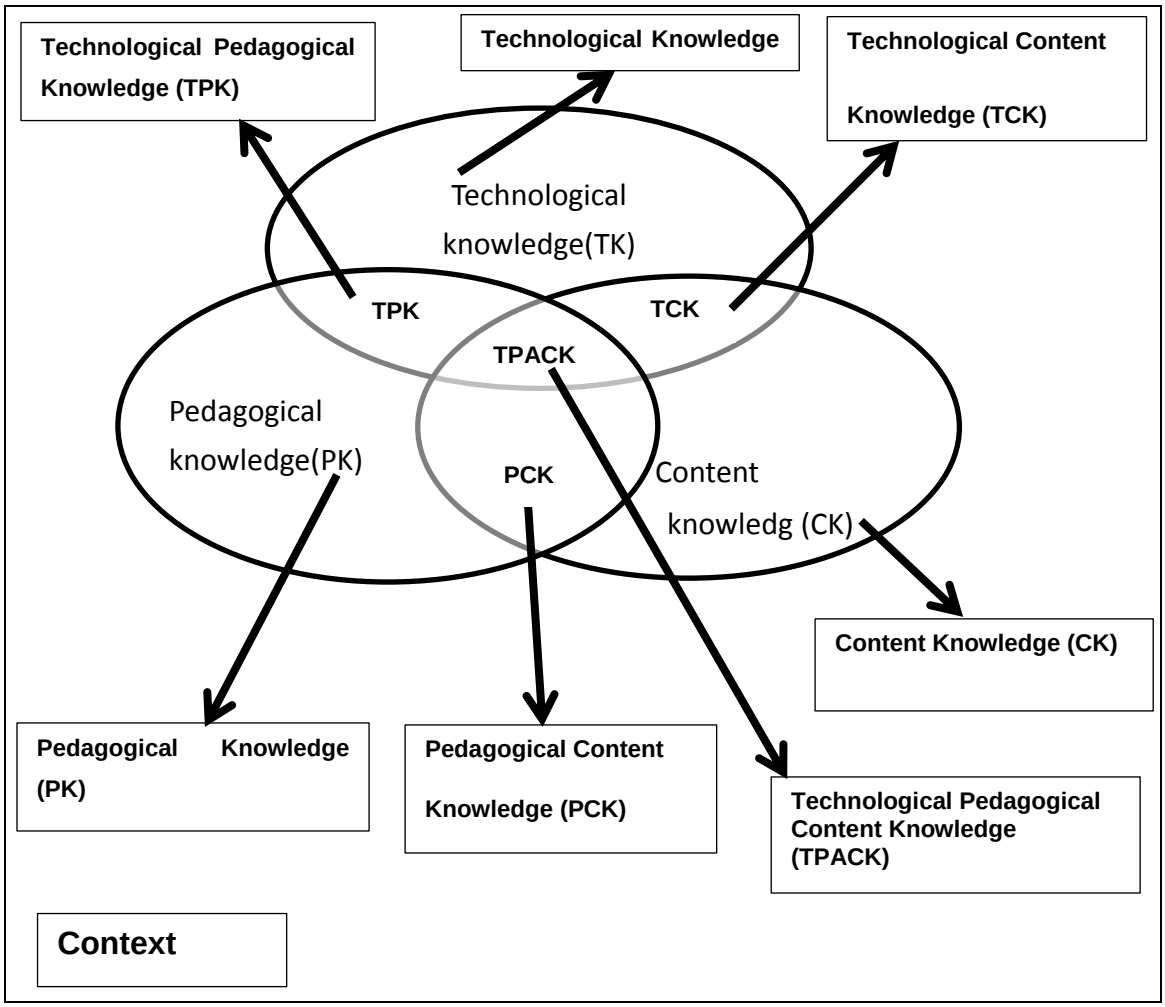


Figure 5. 3: TPACK as a framework for ICT integration

Source: Mishra and Koehler, (2006)

From Figure 5.3, six themes were used to assess the impacts of ICT in teaching and learning. The six themes were -Technological (technological resources that were used by the school), Pedagogical (methods of teaching that was used by teachers when teaching Science), Content (content that was taught during that period and the use of technology in it), Pedagogical content, Technology Pedagogical, Technological content and Technological pedagogical content. See Section 2.8 on the conceptual framework.

The data that was collected showed that all aspects of TPACK are important for successful integration of ICT. When teachers are preparing their lesson, content knowledge is required. During their preparation they must have pedagogical knowledge, they must know how they group learners on the use of ICT. When one use technology resources, they must have technological knowledge. It was revealed in the collected data that all the above knowledge concepts are crucial when one is integrating ICT in teaching and learning. The following are findings per data collecting instruments where TPACK was used to categorise questions per instrument, refer to Section 3.5 of Chapter 3.

5.4.1. Interviews for teachers

The main aim of the researcher when interviewing teachers was to find their attitudes, benefits and challenges towards ICT integration in teaching science, refer to Section 4.3.1 for results. Even though people are diverse, the following is a summary of the findings:

Attitudes and benefits

The attitudes and benefits regarding the teachers were summarised from the responses of questions 5, 6, 9 and 13 which were generated to find the attitudes of the teachers towards ICT integration in teaching, refer to appendix P for the results. The same questions 5, 6, 9 and 13 were amongst the other questions which were categorised within the TPACK components when data was collected from teachers. Question 5 was within content knowledge (CK), question 6 within the technological knowledge (TK), question 13 within technological content knowledge (TCK) and question 9 within TPACK.

Teachers believed that ICT integration makes teaching most of the concepts very easy. They believed that ICT enhanced the delivery of the content because of the videos, animation and sound that draw learners' attentions to learning. Teachers do not waste much time trying to put together teaching aids, ICT integration comes with the whole package if the lesson is well planned. Teachers have enough ICT resources to utilise during ICT integration. They get enough support from school leadership and technicians. There are challenges which need serious attention of school leadership.

Challenges

The main challenges were based on questions 4 and 14. Question 4 was based more on the component of pedagogical knowledge of teachers. Teachers find it challenging to plan having different methods of teaching for different learners with the integration of ICT because most of learners are computer illiterate. They take much time teaching learners how to use tablets effectively in learning, by the time they come to content it would already be late.

Other challenges are covered under the context of question 14. The issue of electricity cuts disturbs the whole system. When there is no electricity, there would be no lesson where ICT would be integrated. Sometimes the WI-FI would be down which means there would be no connections and no lessons. Lesson observations were done by the researchers to collect more information for the study.

5.4.2. Lesson observations

The lesson observations followed teachers' interviews, refer to Section 4.3.2 of Chapter 4 for results. The researcher aimed to observe how ICT resources were used during ICT integration, which resources were used, were the learners practically involved during integration and what were the attitudes, benefits, and challenges during ICT integration. Refer to Appendix P for results.

Attitudes and benefits

The lesson observation questions covered TPACK components. Questions 1 and 2 fell within TPACK, questions 3, 6 and 7 within technological knowledge (TK), question 4 within content knowledge (CK) and questions 5 and 9 within pedagogical knowledge (PK). Questions in TPACK were based on how the

lessons were introduced with the ICT integration (technological and content knowledge) (TCK), were the lesson preparation done using ICT resources (technological knowledge) (TK) and which methods were used by the teachers to teach learners (pedagogical knowledge) (PK)? The summary of results follows:

Teachers introduced their lessons very well using laptops and smartboards. The objectives of the lessons were clearly stated. Teachers demonstrated good skills, knowledge and understanding of ICT integration during teaching and learning. Lessons were prepared, and laptops were used. Learners were involved during questions and answers where they were giving answers, some could even use the smartboard to answer.

Since the content was on acids and bases, and the separation of mixtures experiments were done without any ICT resource. They were doing practical work.

Challenges

Some of the challenges were experienced at some stage. The WI-FI was down, learners' tablets could not connect so they were put back without being used. Electricity cuts gave the schools the problems because for ICT resources to work there must be electricity. Learners used their workbooks for class work. Most of the learners were not familiar with the tablets, they were struggling which was consuming time for the lesson to be taught. They were given handouts and they were answering on the classwork exercise books. The teachers completed the questionnaires.

5.4.3. Teacher questionnaire

All teachers who were presenting the lessons completed the questionnaire. The aim of the researcher was to find out if there would be a link between the information which collected from teachers' interviews, lesson observations and teachers' questionnaires. Refer to Section 4.3.3 in Chapter 4 for results. Questions 1, 2, 3, 6 and 24 were based on the pedagogical knowledge (PK). Questions 4, 9, 17 and 23 were based on the technological pedagogical knowledge (TK). Questions 6, 8, 21, 22 and 26 were based on the technological content knowledge (TCK). The summary of results is as set out below.

Attitudes and benefits

Teachers disagreed that ICT integration was unnecessary additional work to their daily activities. They added that integration is not even obstacle in teaching. They said working with ICT resources would be overwhelming if the challenges they sometimes come across during implementations were attended on time to by leadership of the schools. According to them, ICT integration helped learners to acquire a deeper understanding and insight of science in Grade 7.

Challenges

Teachers alluded to the fact that the challenges they encountered during ICT integration undermine the successful implementation of science in Grade 7. Some teachers had concerns about the absence of motivation and a reward system to encourage them in ICT integration in Science Grade 7. Planning on using ICT resources takes much of their time. When the WI-FI was down or smartboards were not working, they needed to use the whiteboard but having prepared to use the smartboard that was a problem. Some learners became used to the videos and got bored instead of being stimulated.

5.4.4. Learners' focus groups

The researcher collected in-depth qualitative data about the perspectives, attitudes, and experiences of learners about the impacts of technology integration in their learning of Science. Refer to Section 4.3.4 of Chapter 4 for results.

Questions 2, 3, 4 and 17 were based on the technological knowledge (TK). Questions 3, 5, 8, 11 and 13 were based on the technological content (TCK). Questions 1, 3, 6 and 11 were based on the pedagogical knowledge (PK) that is applied by teachers during the lesson. The following is the summary of results.

Attitudes and benefits

Learners are excited with the use of technology in their classrooms. Most of the learners benefit a lot because watching videos of how plants grow gives them a clear understanding rather than trying to figure out what the teacher explains. Learners can search for the information on their own if they are given tablets.

From the internet, they find all the information they want, when they use textbooks the information is limited.

Challenges

The issue of electricity cuts disturbs the whole system. When there is no electricity, there would be no lesson where ICT would be integrated. Sometimes the WI-FI would be down which means there would be no connections and no lessons. Learners complained about the full supervision from the side of teachers when they were using tablets. Most of the learners were watching videos that were not part of the lesson, it caused disturbances in the classroom. Some teachers are computer literate, some learners must help the teachers how to use the smartboard.

The ICT Coordinators completed questionnaires.

Contexts of the cases

5.4.5. ICT coordinator

The ICT co-ordinators of both cases answered the questionnaires. The aim of the researcher was to find out the view of the ICT co-ordinators concerning ICT integration in their schools. For the questionnaires refer to Appendix L. The data gathered from the ICT co-ordinators helped the researcher to have more information on the context of the cases.

Attitude and benefits

The ICT coordinators gave the information concerning the context of the cases. According to ICT coordinators, schools are well equipped with ICT resources to ensure the capability of learners to use technology to its fullest potential. The schools have enough technicians for teachers to get enough help anytime they need assistance. Coordinators alluded to the fact that videos and 3D visuals of ICT helped learners to concentrate and at the same time they would be learning without being forced. Learners enjoyed and were excited about learning.

5.4.6. Principals' questionnaire

The principals of both cases answered the questionnaires. The aim of the researcher was to find out the view of the principals concerning ICT integration in their schools. For questionnaires refer to appendix M. The data gathered from the principals helped the researcher to have more information on the context of the cases.

Attitudes and benefits

The principals agreed that THE Gauteng Department of Education's vision encourages every stakeholder to participate effectively in ICT integration. There is a clear direction from DBE on ICT guideline policies for the implementation of technology in teaching. School Management Teams and School Governing Bodies are supporting and encouraging every stakeholder to participate effectively in ICT integration.

Challenges

The challenges that the cases are facing were the same for all participants. At some stages, WI-FI connection would be down they would totally not able to connect and the cuts of electricity where ICT resources need electricity to function.

5.4.7. Recommendations

All the participants recommended that it would be better if the schools had generators to supplement when there was a cut of electricity. Much learning time was consumed when there was a cut of electricity. The WI-FI connection should be the priority because without WI-FI there would be no proper lessons. Unwanted information that learners end up keeping themselves busy with should be blocked. More teachers and learners must be trained on how to use ICT resources beneficially to education.

5.4.8. Conclusion

The conceptual framework was primarily used as a lens for a deeper understanding of the complex and challenging theory of ICT integration in education specifically for Science. All the components of TPACK took part in extracting information that the researcher needed from both cases. There are exceptions though for the next research.

5.5. Exceptions

The researcher must be ready for any change concerning collection of data. There are many activities that are taking place in the schools, so the researcher needs to be flexible. It became so challenging to collect data because participants are people, not objects. Sometimes when the researcher visited the school will she would find that the participant was not there, or they were busy with something else and she could not force them to abandon what they were doing and attend to the researcher.

5.6. Shortcomings and limitations

5.6.1. Shortcomings

The study had shortcomings because of the busy schedule in schools. Sometimes the time of the lesson would not be at the planned time. Activities that were taking place after school like staff meeting or workshop of teachers gave the researcher a tough time. The changes in timetable caused problem for the researcher. In one of the cases after the researcher had discussions with participants and consent letters were signed, the timetable was changed. One teacher instead of two teachers was left teaching Science.

5.6.2. Limitations

At the time of this study, there were only two primary schools where ICT integration were piloted. It restricted some other school from taking part in the study. The researcher worked with the participants of the two cases to collect the data. The time available to collect the data limited the researcher. The researcher had to go back to the school timeously to finish the collection of the data. The Wi-Fi connection was problematic for participants. They would opt for the green board to continue with teaching and learning. Electricity cuts were limiting participants during teaching and learning.

5.7. Recommendations

More teachers and learners need to be trained to be computer literate. Ongoing monitoring of Wi-Fi connections should be done to avoid waste of teaching and learning time. Extra safety measures must be put in place in other for the school to

use tablets without any fear that tablets can be stolen. Tablets must be given to learners for continuous educational usage even if they are at home. If possible, all uneducative information should be blocked in the tablets to discipline learners from accessing it.

As generative mechanisms from a critical realist perspective have causal powers, the lack of successful ICT integration due to causal factors in the social and artefactual reality often has unintended outcomes such as unsuccessful integration of ICT in the teaching and learning of science, often accounted for by the interactions between the real mechanisms and the events or actual reality, as described in Chapter 2.

Choosing to use computers characterized by drill, practice and remediation to support learning and not incorporating them in the curriculum often has dire consequences or outcomes, because teachers with their traditional pedagogical beliefs remain as instructivists (or teacher centred) and not constructivists (learners centred), (Ertmer, 2005; Sang et al., 2010; Tondeur et al., 2008). Learners indicated that it would be helpful if they could be given tablets to use them at home for continuous practice.

More teachers and learners must have basic computer skills for the smooth run of integration. Much time is wasted in teaching computer skills rather than content. Teachers should be trained on more teaching methods on ICT integration. Learners must be practically involved in using ICT resources.

5.8. Benefits to the field of study

The major benefit of using ICT in science education is that it expands the pedagogical horizons and resources available to science teachers (Al-Alwani, 2005). If ICT in science is properly integrated during the conventional pedagogical practices, as discussed above, the benefits of the use of ICT in schools are immense as compared to conventional teaching and learning in science (Bingimlas, 2009).

The study helped with the description of two cases that the use of ICT piloted. Any challenges identified need attention from leadership of the schools and the Gauteng Department of Education. It is up to teachers to reconsider the way of teaching by integrating ICT in order to enhance effective teaching and learning in school

(Department of Basic Education, 2011). Teachers will select appropriate ways of teaching with ICT integration.

5.9. Proposed new research

The new research should be based on more schools rather than on two schools for the generalisation of the findings.

5.10.Conclusion

The main purpose of this research was to explore if ICT was indeed supporting the learning and teaching of natural science in Grade 7 in township schools where the Paperless project has been initiated. It is globally accepted that the integration of ICT in education improves learners' performance (Earle, 2002).

Schools are integrating ICT to improve conventional teaching and learning but it somehow may add to learners' failure. They must always track the effectiveness of ICT integration to inform policy formation for sustainability. Teachers and learners coping mechanisms must be examined for integration to succeed.

This research explored the key success elements (indicators/factors), among others, from the TPACK model, with causal powers to ensure the success of ICT integration. Perceptions of teachers, learners and other stakeholders were studied in the areas where new technology infrastructure which included computer tablets has been made available to Grade 7 learners. When this project started during 2015, the aim was that learning can take place anytime, anyhow, anywhere and as needed by learners, thereby promoting a learner-centred environment where there should be continuous management of the project.

Factors that affect teachers' quality were found to be: teacher's lack of ICT training, attitudes, beliefs, self-efficacy and lack of teacher's motivation. Based on this, teachers are faced with choices of what the optimal pedagogy is, that is suitable to their situation considering the lack of resources and infrastructure. Teachers with low quality possess a low coping mechanism hindering them to make ICT integration effective.

If factors that are responsible for the ICT ineffectiveness are not carefully evaluated, monitored, tracked and uprooted, the versatility and utility of ICT in education will consequently continue to be undermined and eroded, resulting in increased learner failure due to the lack of interest and motivation in science and maths subjects. The economics of countries would, hence, be affected by the lack of qualifications and rightful skills. The need arises for this research to explore key success factors leading to the effective integration of ICT in natural science at schools. The evaluation, monitoring, and tracking of the effectiveness of ICT in education should go a long way in addressing the factors contributing to failure and demotivation of learners in schools in the piloted areas.

Worldwide, the integration of ICT in education is seen as a major resource for effecting necessary changes (content, pedagogy, and outcomes) in the conventional teaching and learning process, as presented by existing literature in Chapter 2 of the current research (Newhouse, 2002). Much work needs to be done by all stakeholders of the school for the ICT integration to be successful.

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APPENDIX A: Personal declaration of responsibility

Title of research: ICT integration in Grade 7 Science teaching to support learning

I declare that I am conscious of the goals of the Research Ethics Committee in the Faculty of Education to:

- Develop among students and researchers a high standard of ethics and ethical practice in the conduct of educational research.
- Cultivate an ethical consciousness among scholars especially in research involving human respondents.
- Promote among researchers a respect for the human rights and dignity of human respondents in the research process.

I subscribe to the principles of:

- Voluntary participation in research, implying that the participants might withdraw from the research at any time.
- Informed consent, meaning that research participants must always be fully informed about the research process and purposes and must give consent to their participation in the research.
- Safety in participation put differently that the human respondents should not be placed at risk or harm of any kind. E.g. research with young children.
- Privacy, meaning that the confidentiality and anonymity of participants should be protected.
- Trust, which implies that the participants will not be subjected to any acts of deception or betrayal in the research process or its published outcomes.

I understand what plagiarism entails and am aware of the University`s policy in this regard. I undertake not to make use of another person`s work without acknowledgment or to submit it as my own. I also undertake not to allow anyone to copy my work with the intention of using it as his/her own work.

I understand that the data collected during research become the property of the University of Pretoria and I undertake to transfer all raw data and documents related to research for safekeeping as required by the Faculty of Education.

I understand that any amendment to the approved protocol needs to be submitted to the Ethics Committee for review prior to data collection. Non-compliance implies that approval will be null and void.

V.N Makwela	_____	_____
Applicant	Signature	Date
Dr. R Callaghan	_____	_____
Supervisor	Signature	Date

APPENDIX B: Ethical clearance certificates

For administrative use only:
Reference no: D2017 / 356
enquiries: 011 843 6503

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GDE RESEARCH APPROVAL LETTER

Date:	**10 November 2016**
Validity of Research Approval:	**6 February 2017 to 29 September 2017**
Name of Researcher:	**Makwela V.N.**
Address of Researcher:	**45 Blesbok Avenue; Clayville East; Olifantsfontein; 1666**
Telephone / Fax Number/s:	**084 873 1391**
Email address:	**nomcebomakwela@yahoo.com**
Research Topic:	**ICT integration in Grade 7 Natural Science teaching to support learning**
Number and type of schools:	**TWO Primary Schools**
District/s/HO	**Ekurhuleni North**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. *The District/Head Office Senior Manager/s concerned, the Principal/s and the chairperson/s of the School Governing Body (SGB.) must be presented with a copy of this letter.*
2. *The Researcher will make every effort to obtain the goodwill and co-operation of the GDE District officials, principals, SGBs, teachers, parents and learners involved. Participation is voluntary and additional remuneration will not be paid;*

Approved
2016/11/11

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	CLEARANCE NUMBER: **SM 16/11/01**
DEGREE AND PROJECT	MEd Paperless classroom experiences in Grade 7 science in township schools
INVESTIGATOR	Ms Victoria Nomcebo Makwela
DEPARTMENT	Science, Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	8 February 2017
DATE OF CLEARANCE CERTIFICATE	04 October 2017

CHAIRPERSON OF ETHICS COMMITTEE: Prof Liesel Ebersöhn

CC

Ms Bronwynne Swarts
Dr Ronel Callaghan

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

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

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Fakulteit Opvoedkunde
Lefapha la Thuto

Ethics Committee
8 February 2017

Dear Ms N Malowela

REFERENCE: SM 16/11/01

Your application was carefully considered by the Faculty of Education Ethics Committee and the final decision of the Ethics Committee is:

Your application is approved.

This letter serves as notification that you may continue with your fieldwork. Should any changes to the study occur after approval was given, it is your responsibility to notify the Ethics Committee immediately.

Please note that you will have to fulfil the conditions specified in this letter from the Faculty of Education Research Ethics Committee. The conditions include:

1) The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment (Section E) for approval by the Committee.
   - Any amendments to this approved protocol need to be submitted to the Ethics Committee for review prior to data collection. Non-compliance implies that the Committee's approval is null and void.
   - Final data collection protocols and supporting evidence (e.g. questionnaires, interview schedules, observation schedules) have to be submitted to the Ethics Committee before they are used for data collection.

2) The researcher should please note that this decision covers the entire research process, until completion of the study report, and not only the days that data will be collected.
3) Should your research be conducted in schools, please note that you have to submit proof of how you adhered to the Department of Basic Education (DBE) policy for research.

4) The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Please note that this is not a clearance certificate.
Upon completion of your research, you need to submit the following documentation to the Ethics Committee:

- **Integrated Declaration Form (Form D08),**
- **Initial Ethics Approval letter and,**
- **Approval of Title.**

On receipt of the above-mentioned documents you will be issued a clearance certificate. Please quote the reference number **SM 16/11/01** in any communication with the Ethics Committee.

Best wishes

Prof Liesel Ebersöhn
Chair: Ethics Committee
Faculty of Education

APPENDIX C: Permission to visit school

Faculty of Education

Department SMTE
Groenkloof campus
Pretoria 0002
Republic of South Africa
Tel (012) 420 – 5693
Fax (012)420 5621

Date: 13 March 2016

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO CONDUCT THE RESEARCH IN YOUR SCHOOL, ON ICT INTEGRATION IN GRADE 7 SCIENCE TEACHING TO SUPPORT LEARNING.

My name is Victoria Nomcebo Makwela, a registered MEd student at the University of Pretoria. I wish to apply for the permission to conduct research at your school. My research project will involve Grade 7 learners who are doing natural science. My research topic is on ICT integration in Grade 7 Science teaching to support learning.

This study will involve the observation of the teacher and learners in the classroom during Science period in Grade 7. I will be a passive participant who will do audio recording, video recording and observing while the teacher and the learners are busy in the class. I would like

to come once in two weeks. During the period, I would also go through prescribed books and other policy documents that are used in the teaching of Science in Grade 7.

This research project will also involve interviews with natural science teachers in Grade 7 and focus groups with 6-7 learners who will be randomly selected. Workbooks for learners who will be selected for focus group interviews would be checked by the researcher for document analysis.

I hope you will find the above request in order.
Yours sincerely
Victoria Makwela

Permission for research

We, _____, hereby give/not to give our consent for the school to participate in the study. We are assured of confidentiality, anonymity and that the school can withdraw anytime for any reason if we do not wish to continue with the research.

Signature: _____ Date: _____The Principal

Signature: _____ Date: _____ The SGB Chairperson

Researcher: _____ Date: _____

APPENDIX D: Letter of consent to the teachers

Faculty of Education

Department SMTE
Groenkloof campus
Pretoria 0002
Republic of South Africa
Tel (012) 420 – 5693
Fax (012)420 5621

Date: 13 March 2017

Title of research: ICT integration in Grade 7 Science teaching to support learning

Dear Educator

RE: REQUEST TO PARTICIPATE IN A RESEARCH PROJECT.

This is to request your participation in the research project that will take place in your school. The project will be for technology integration in Science in Grade 7 class. This request is for you since you are teaching Science in Grade 7. The project will be during afternoon classes that are done for extra lessons.

The aim of the project is to try to find ways of improving the interest of learners in learning. We hope you are aware that the rate of failure in our schools is escalating year by year. If you are interested in participating in this project, your role will be in terms of teaching and learn Science

using modern ICT. Your involvement in this project will not affect your teaching time since it will take place during enrichment classes.

The researcher will come to your class and observe to gather the data that is needed. There will be one on one interview after observation. Videotape will also be used to gather some of the data. You will be notified of the visit.

Yours sincerely
Name of a researcher: Victoria Nomcebo Makwela

Signature: _____

Permission for research

I, _____, hereby give/not give my consent to participate in the study. I am assured of confidentiality, anonymity and that I can withdraw anytime for any reason if I do not wish to continue with the research.

Signature: _____ Date: _____

Researcher: _____ Date: _____

APPENDIX E: Letter of consent to the parents

Faculty of Education

Department SMTE
Groenkloof campus
Pretoria 0002
Republic of South Africa
Tel (012) 420 – 5693
Fax (012)420 5621

Date: 13 March 2017

Title of research: ICT integration in Grade 7 Science teaching to support learning.

Dear Parent(s)/Guardian(s)

RE: REQUEST FOR PERMISSION TO INVOLVE YOUR CHILD IN A RESEARCH PROJECT.

I am writing to ask your permission for your child to participate in a research project aimed at addressing the poor performance of learners in Science. In this project, your child will be taught Science using modern technology.

In this project, lessons will be presented after school, as part of the learner after school enrichment project. Your child's school is already part of this after-school enrichment project. This means that if you allow your child to participate in this research project is not going to change his/her daily schedule. Participation is voluntary, should it happen that they wish to discontinue they will be at liberty to do so at any time.

It would be beneficial and enjoyable to your child to participate in this project since it will be educational he/she will gain knowledge. There is nothing that will be paid by the parents and no responsibility is expected from the parents concerning the project. Learners are not going to be paid for participation.

Any information that will be collected during the project will be used for this research only. No information or results that will be shared with school staff. Participation of your child will not affect the assessment of your child. Records will not be kept in the school.

Yours sincerely
Name of a researcher: Victoria Nomcebo Makwela
Signature: _____

Permission for research

I, _____, hereby give/not give my consent for my child to participate in the study. I am assured of confidentiality, anonymity and that I can withdraw anytime for any reason if I do not wish to continue with the research.

Signature: _____ Date: _____

Researcher: _____ Date: _____

APPENDIX F: Letter of assent to the learners

Faculty of Education

Department SMTE
Groenkloof campus
Pretoria 0002
Republic of South Africa
Tel (012) 420 – 5693
Fax (012)420 5621

Date: 13 March 2017

Title of research: ICT integration in Grade 7 Science teaching to support learning

Dear Learner

RE: REQUEST FOR PERMISSION TO INVOLVE YOU IN A RESEARCH PROJECT.

I am writing to ask your permission for you to participate in a research project aimed at addressing the poor performance of learners in Science. In this project, you will be taught Science using technology. Participation is voluntary, should it happen that you wish to discontinue, you will be at liberty to do so at any time.

In this project, lessons will be presented after school, as part of the learner after school enrichment project. Your school is already part of this after-school enrichment project. This means that if you agree to participate in this research project, it is not going to change your daily schedule.

It would be beneficial and enjoyable to you to participate in this project since it will be educational you will gain knowledge. There is nothing that will be paid by your parents and no responsibility is expected from your parents concerning the project. Learners are not going to be paid for participation.

Any information that will be collected during the project will be used for this research only. No information or results that will be shared with school staff. Your participation will not affect your assessments. Video recordings, audio recordings, results collected during interviews will not be kept in the school.

Yours sincerely

Name of a researcher: Victoria Nomcebo Makwela

Signature: _____

Permission for research

I, _____, hereby give/not give my consent to participate in the study. I am assured of confidentiality, anonymity and that I can withdraw anytime for any reason if I do not wish to continue with the research.

Signature: _____ Date: _____

Researcher: _____ Date: _____

APPENDIX G: Letter of assent to the ICT Co-ordinator

Faculty of Education

Department SMTE
Groenkloof campus
Pretoria 0002
Republic of South Africa
Tel (012) 420 – 5693
Fax (012)420 5621

Date: 13 March 2017

Title of research: ICT integration in Grade 7 Science teaching to support learning

Dear ICT Co-ordinator

RE: REQUEST TO PARTICIPATE IN A RESEARCH PROJECT.

This is to request your participation in the research project that will take place in your school. The project will be for technology integration in Science in Grade 7 class. This request is for you since you are coordinating ICT at your school. The project will be during afternoon classes that are done for extra lessons.

The aim of the project is to try to find ways of improving the interest of learners in learning. We hope you are aware that the rate of failure in our schools is escalating year by year. If you are interested in participating in this project, your role will be in terms of giving the researcher answers concerning IT in your school. Your involvement in this project will not affect your working time.

The researcher will come to computer laboratory or classes and observe to gather the data that is needed. There will be one on one interview. Videotape will also be used to gather some of the data. You will be notified of the visit.

Yours sincerely
Name of a researcher: Victoria Nomcebo Makwela

Signature: _____

Permission for research

I, _____, hereby give/not give my consent to participate in the study. I am assured of confidentiality, anonymity and that I can withdraw anytime for any reason if I do not wish to continue with the research.

Signature: _____ Date: _____

Researcher: _____ Date: _____

APPENDIX H: Teachers Interview

Interview with teachers: **Addressing: Attitudes, impacts, and challenges**

Name of the school: School A or B Name of the teacher: Teacher X

Time started: _____ Time ended: _____

Thank you very much for giving me the opportunity to interview you. It would be appreciated if you would answer the questions briefly and thoroughly. If there is a question that you do not understand feel free to ask for clarity. All information would be treated in confidence and would be used for academic purposes only. It is hoped that the research would provide input for ICT policy formulation and advancement.

1. How many years do you have in teaching?

Answer: _____

2. How many years of experience do you have teaching Science in grade 7?

Answer: _____

3. Is there a clear direction in DoE ICT guideline policies for implementation of technology in teaching?

Please elaborate:

_____

_____

4. How much time do you spend after school hours using ICT doing your natural science work from Monday to Friday?

Please elaborate:

_____

_____

5. According to your own understanding is there a need for ICT integration in learning of Science in school? Yes/No. _____

Please elaborate:

_____

_____

6. How does the implementation of technology in your class change the attitude of the learners in learning Science?

Please elaborate:

_____

_____

7. Do you have enough ICT equipment for proper integration?

_____

_____

8. What type of ICT equipment do you use during Science period in your classroom?

Explain:

_____

_____

9. What type of changes do you think ICT integration in Science teaching and learning has?

Elaborate:_____

_____

10. How is the ICT technical support for teachers and learners for successful integration?

Please elaborate:

_____

_____

11. How does leadership's vision encourage every stakeholder to participate effectively in ICT integration? Please elaborate:

_____

_____

12. How is the support of technicians and administrators in teachers and learners with the introduction of new technology?

Please elaborate:

_____

_____

13. Do you think ICT integration in Science teaching can support learning in schools?

Please elaborate:

_____

_____

14. What are the problems or limitations which you have identified with the use of ICT as a teaching model? Please elaborate:

Please elaborate

_____

_____

_

15. What recommendations will you like to make to address the problems?

_____

_____

APPENDIX I: Observation sheet

Observation sheet **Addressing: Attitudes, impacts, and challenges** **Name of the school:**

School A or B **Name of the teacher: Teacher X** **Date:_____**

Grade: 7___ **Number of learners: _____**

Subject: Science **Observer: Mrs Makwela V.N.**

Time started:_____ **Time ended:_____**

1. The introduction of the lesson by the teacher, if it shows good subject knowledge, the way in which ICT could be integrated into teaching Science.

Description/Comments_____
_____

2. Is the learning objective clear and why the lesson in terms of skills, knowledge and understanding of ICT?

Description/Comments_____
_____

3. What types of ICT resources are available in the class?

Description/Comments_____
_____

4. Which Science content is taught during the lesson?

Description/Comments_____
_____

5. Which method(s) of teaching the teacher uses?

Description/Comments_____
_____
_____

6. Which types of ICT resources the teacher use during lesson delivery, are they appropriate resources for the lesson?

Description/Comments_____
_____
___

7. Do ICT resources in the class function reliable?

Description/Comments_____
_____

8. Are the resources deployed and organised effectively for use of all learners in the class?

Description/Comments_____
_____

9. Does the teacher involve learners actively to use ICT effectively and creatively in other for learners to understand the content?

Description/Comments_____
_____

10. What problems or limitations have you identified in the use of ICT in teaching and learning?

Description/Comments_____
_____

APPENDIX J: Teachers' Questionnaire

Questionnaire for teachers Addressing: Attitudes, impacts and challenges

Name of the school: School A or B **Name of the teacher: Teacher X**

Time started: _____ **Time ended: _____**

Questionnaire

For office use only

Respondent's number	V1		01-04
School number	V2		05-07

This questionnaire investigates whether the ICT that was integrated into your school curriculum is supporting the Grade 7 Natural Science teaching and learning. The prime objective of the research is to illuminate on any noticeable impacts, attitudes, and challenges faced by teachers and learners since ICT was integrated.

It would be appreciated if you would answer the questions briefly and thoroughly. All information would be treated in confidence and would be used for academic purposes only. It is hoped that the research would provide input for ICT policy formulation and advancement.

Thank you in advance
Sincerely
V N Makwela (Mrs)
Masters student
Department of Education, University of Pretoria

Instruction for completion

1. Please answer all questions as honestly as possible.
2. When asked to comment please keep it as short as possible.
3. Mark with a cross on shaded space provided.
4. Please answer all questions regarding your specific section, if possible to enable accurate analysis and interpretation of data.

1. Biographical question

What is your gender?	
Male	1
Female	2

2. What is your age group?	
20 - 29	**1**
30 - 39	**2**
40 - 49	**3**
50 - 59	**4**
60 - 65	**5**

3. Science teaching experience in year(s)	
1 - 2	**1**
2 - 5	**2**
5 - 8	**3**
9 - 14	**4**
15 – 20	**5**
More than 20	**6**

4. ICT in Science for Grade 7 is an unnecessary addition to our work and in some cases even an obstacle in teaching.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

5. It is important to use simulations and animations in teaching science since it facilitates learner ’s acquisition of scientific processes and skills.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

6. Slow adoption of ICT in Grade 7 Science can be attributed to plain reluctance and aversion to technology and faith in the old-fashioned method of teaching	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

7. Working with ICT in the classroom is something that overwhelms me.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

8. ICT does help learners to acquire deeper understanding and insight of Natural Science in Grade 7.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

9. Teachers do not have enough time to integrate ICT in their teaching.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

10. Teachers with learner-centered pedagogical beliefs are successful in achieving high pass rates after integrating technology in Grade 7 Science.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

11. Challenges/barriers to integration undermine the successful implementation of Natural Science in Grade 7.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

12. The Department of Education ICT Policies supports the integration process within schools.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

13. Teachers with high self-efficacy are more effective in supporting the learning of Grade 7 Science.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

14. Barriers that Natural Science teachers face are the absence of motivation and reward system to encourage the use of ICT.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

15. What are some of the constraints to using ICT in your teaching Natural Science in Grade 7?

Elaborate_____

_____

16. What are the learners' challenges during ICT integration in Grade 7 Natural Science?

    Elaborate_____

    _____

17. I can use technology resources to facilitate higher order and complex thinking skills, including problem solving.

    Please elaborate

    _____

    _____

18. Teachers receive salary incentives to encourage implementation and use of ICT in Natural Science.

    Please elaborate

    _____

    _____

19. The integration of ICT is supporting teaching and learning of Grade 7 Science.

    Please elaborate

    _____

    _____

20. What guidelines do educators need when integrating ICT in Grade 7 Science?

    Please elaborate_____

    _____

21. Since you started using ICT do your learners in Grade 7 Natural Science achieve better pass rate than prior years?

Yes	**1**
No	**2**

22. Learners are more motivated when using ICT.

Yes	**1**
No	**2**

23. Lack of training and education in the use of ICT hampers successful integration.

Please elaborate

_____

_____

24. I am content with traditional way of teaching.

Please elaborate_____

_____

25. ICT performance indicators should be set up to help in assessing which initiatives are more likely to contribute towards a successful integration.

Please elaborate_____

_____

26. When ICT is integrated slow learners participate in discussions, make comments and sometimes take the lead in presentations. Please elaborate

_____

_____

27. The integration of ICT in Grade 7 Science motivates and focuses students who show low interest in schoolwork.

Please elaborate

_____

_____

APPENDIX K: Focus group for learners

Interview (Focus group for learners)

Addressing: Attitudes, impacts, and challenges

Name of the school: school A Name of the group: _____

Time started:_____Time ended:_____

Group No._____

Thank you very much for giving me the opportunity to interview you. It would be appreciated if you would answer the questions briefly and thoroughly. If there is a question that you do not understand feel free to ask for clarity. All information would be treated in confidence and would be used for academic purposes only. It is hoped that the research would provide input for ICT policy formulation and advancement.

1. I believe technology is helping learners become innovative in the classroom as compared to conventional teaching and learning.

   Briefly explain: _____

   _____

2. What type of ICT resources do you use during Science period in your class?

   List: _____

   _____

3. What are your perceptions about the recently integrated ICT in Grade 7 Science?

   Comment: _____

   _____

4. Do you see yourself achieving better results because of learning with technology?

   Comment: _____

   _____

5. When ICT is used there is an improvement in learner's attitude on the content of the subject

   Comment: _____

   _____

6. Do you think teachers need to be more skillful on the use of computers before using ICT for Science?

   Briefly explain: _____

   _____

7. What obstacles do you see hindering the use of ICT in Grade 7 Science?

   Comment: _____

   _____

8. Do you think as a learner, you had more computer training skills before using ICT for Science?

   Comment: _____

   _____

9. Can technology distract you from learning?

Briefly explain: _____

_____

10. Learners like to discover things by themselves. How does technology impact on that?

Comment: _____

_____

11. Learners use ICT largely for non-subject related activities

Comment: _____

_____

12. What impact do you think animations and simulations have on your grade 7 natural science ICT?

Comment: _____

_____

13. When technology is used I understand better the natural science concepts than when books are used.

Comment: _____

_____

14. What impact does ICT professional training and development on the learners' performance?

Comment:

_____

15. What are the problems or limitations which you have identified with the use of ICT as a teaching model?

Comment: _____

_____

16. What recommendations would you like to make to address the problems?

Briefly explain: _____

_____

17. According to your own understanding is there a need for ICT integration in learning of Science in school? Yes/No. Give a reason for your answer.

Briefly explain: _____

_____

18. How is the ICT technical support for teachers and learners for successful integration?

Briefly explain: _____

_____

APPENDIX L: Questionnaire of ICT coordinator

Faculty of Education

ICT Co-ordinator's questionnaire

Addressing: Attitudes, impacts and challenges **Name of the school: _____**

Name of the Co-ordinator: _____ **Date:_____**

Grade: 7___ **Number of learners: _____**

Subject: Science **Researcher: Mrs Makwela V.N.**

Time started:_____ **Time ended:_____**

Thank you very much for giving me the opportunity to interview you. It would be appreciated if you would answer the questions briefly and thoroughly. If there is a question that you do not understand feel free to ask for clarity. All information would be treated in confidentiality and would be used for academic purposes only. It is hoped that the research would provide input for ICT policy formulation and advancement.

1. How can adequate resources promote effective ICT integration?

Answer: _____

_____

_____

2. Is there any problem on lack of ICT technical support in teachers and learners for successful integration?

Answer:_____

_____

_____
_____

3. Is there a clear direction in DoE ICT guideline policies for implementation of technology in teaching?

Elaborate: _____

_____
_____

4. Does leadership vision encourage every stakeholder to participate effectively in ICT integration?

Elaborate: _____

_____
_____
_____

5. According to your own understanding is there a need of ICT integration in learning of Science in school? Yes/No. _____

Please elaborate:

_____
_____

_____
_____

6. How does the implementation of technology in your school change the attitude of the learners in learning Science?

Please elaborate:

_____

_____
_____
_____

7. Can teachers and learners alone make it without expertise from technicians?

_____
_____
_____

8. What type of ICT equipment's teachers use during Science period in your classroom?

Explain:

_____

_____
_____
_____

9. What type of changes do you think ICT integration in teaching and learning has?

_____
_____
_____
_____

10. How is the ICT technical support for teachers and learners' results to successful integration?

Please elaborate:

_____

_____
_____

11. How does leadership's vision encourage every stakeholder to participate effectively in ICT integration? Please elaborate

_____

_____
_____
_____

12. Do technicians assist teachers and other stakeholders in keeping the ICT pedagogical processes on place?

_____
_____

APPENDIX M: Principals' Questionnaire

Questionnaire for principals **Addressing: Attitudes, impacts, and challenges**

Name of the school: School A or B **Name of the teacher: Teacher X**

Time started: _____ **Time ended: _____**

Questionnaire

For office use only

Respondent's number	V1		01-04
School number	V2		05-07

This questionnaire investigates whether the ICT that is integrated into your school curriculum is supporting the Grade 7 Natural Science teaching and learning. The prime objective of the research is to illuminate on any noticeable impacts, attitudes, and challenges faced by teachers and learners since ICT is integrated.

It would be appreciated if you would answer the questions briefly and thoroughly. All information would be treated in confidence and would be used for academic purposes only. It is hoped that the research would provide input for ICT policy formulation and advancement.

Thank you in advance.
Sincerely
V N Makwela (Mrs)
Masters student
Department of Education, University of Pretoria

Instruction for completion

Please answer all questions as honestly as possible.
When asked to elaborate, please keep it as short as possible.
Mark with a cross on shaded space provided.
Please answer all questions regarding your specific section, if possible to enable accurate analysis and interpretation of data.
1.Biographical question

What is your gender?	
Male	1
Female	2

2.What is your age group?	
20 - 29	**1**
30 - 39	**2**
40 - 49	**3**
50 - 59	**4**
60 - 65	**5**

3. Indicate when did Paperless classroom project start in your school? (years)	
1 - 2	**1**
2 - 5	**2**
5 - 8	**3**

9 - 14	**4**
More than 15	**5**

4.GDE's vision encourages every stakeholder to participate effectively in ICT integration?	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

5.SGB and SMT support and encourage every stakeholder to participate effectively in ICT integration?	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

6.There is a clear direction on DoE ICT guideline policies for implementation of technology in teaching?	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

7.There are problems of lack of ICT technical support to teachers and learners for successful integration?	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

8.ICT is an unnecessary addition to our school and in some cases even an obstacle in teaching.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

9.ICT does help learners to acquire deeper understanding and insight of learning.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

10.Teachers complain a lot of not having enough time to integrate ICT in their teaching.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

11.Teachers with learner-centered pedagogical beliefs are successful in achieving high pass rates after integrating ICT.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

12.Teachers with high self-efficacy are more in the integration of ICT in teaching.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

13.Teachers are motivated and rewarded to encourage the integration of ICT.	
Strongly Disagree	**1**
Disagree	**2**
Neither Agree nor Disagree	**3**
Agree	**4**
Strongly Agree	**5**

14. ICT is an unnecessary addition to our school and in some cases even an obstacle in teaching.
Yes/No.
Please elaborate _____

_____

15. Lack of training of educators or ICT skills in the use of ICT hampers successful integration.

Please elaborate:

_____

_____

16.What are the problems or limitations which were identified with the use of ICT as a teaching model your school as far as you know? Please elaborate

_____

_____

17. What recommendations would you like to make to address the problems/limitations?
Please elaborate:

_____

_____

APPENDIX N: Objective 1

Results on the use of ICT in impacting the gain in Science knowledge for Grade 7.

Teachers' Interviews

Categories	Descriptions	Codes
Year of teaching experience	- 3 years - 4 years =19 years	TAcaA TBcaA TAcaB
Time spent after school hours using ICT doing natural science work from Monday to Friday.	- I hour per day or even more, it depends. - 1 hour to prepare lessons and finding out more information on the internet. = At school it can be 30min to 1 hour since I do most of my planning at home. =1 hour preparing lesson.	TAcaA TBcaA TAcaB TBcaB
ICT technical support for teachers and learners for successful integration	-ICT technical support in terms of ensuring that the devices are in perfect working condition. -We have good support from technical team. =Videos, 3D pictures and animation play an important role in teaching and learning. =Well trained, supportive and knowledgeable.	TAcaA TBcaA TAcaB TBcaB

Observation

Categories	Descriptions	Codes
The introduction of the lesson by the teacher, if it shows good subject knowledge, the way in which	-The introduction shows a vast subject knowledge and the way in which ICT be could be integrated. The teacher prepared her lesson well using ICT.	TAcaA

ICT could be integrated into teaching Science.	- Good introduction to teacher good knowledge and usage of ICT. =Teacher's introduction showed vast knowledge of Natural Science as a subject. Integration of ICT was not done.	TBcaA TAcaB
What types of ICT resources are available in the class?	-Teachers laptop, smart board -Laptop and smart board. = Laptop and smart board	TAcaA TBcaA TAcaB
Which Science content is taught during the lesson?	-Acids, bases and neutral. -Acids, bases and neutral. =Separation of mixtures.	TAcaA TBcaA TAcaB
Which method(s) of teaching the teacher uses?	-Interactive teaching and learning methods -Interactive teaching and learning methods =More of conventional and less of interactive methods	TAcaA TBcaA TAcaB
Do ICT resources in the class function reliable?	-No complaint from the teacher. The researcher observed no problem that was caused by any of the resources used during the lesson. -Yes, the resources that were used during the lesson functioned reliably. There was no problem that was noticed during the lesson. = Not at all times. The laptop was working well, the smart board had problems of not allowing the teacher to type using the keyboard. She used the board to write.	TAcaA TBcaA TAcaB

Are the resources deployed and organized effectively for use of all learners in the class?	-No resources were given to the learners. Learners were using their class work and textbooks during the lesson. -No ICT resources were given to learners to use in class. Learners were using their exercise and textbooks. =No, learners did not use any ICT resources during the lesson. Only the teacher who used laptop and smart board. Learners were actively involved in activity of separating different mixtures using different methods.	TAcaA TBcaA TAcaB

Learners' focus group

Categories	Descriptions	Codes
What type of ICT resources do you use during Science period in your class?	-Mostly we use ah…. our smartboards. =We use smartboards =Sometimes we use our tablets	L2caA L1caB L3caB
Do you see yourself achieving better results because of learning with technology?	-I don't think so because ah.. learners are thinking smartboards are just like, like applying just to playing because they are not concentrating on their school work. -It relies on the person who is using the smartboard or the table. If you do not use the tablets or the tablet responsibility, you will not ah.. achieve your NS subject or you will fail. If and.. if you use that smartboard if you help yourself with that tablet ah.. using it to get textbook researching more things than on NS, Technology, and subjects and helping yourself to achieve more and know things more. -Eeh sometimes its good but sometimes is bad because the majority of us learners use it	L4caA L2caA L2caB

	for bad things like pornography and games most of us. =Yes because if we don't understand other words we can search. =We can search for the words that we do not understand we can search it and know it. =I think our performance has improved because we catch up with the latest news about technology. =We can search for words that are difficult to us.	 L5caB L1caB L3caB L7caB
Do you think teachers need to be more skillful on the use of computers before using ICT for Science?	-I think yes it is important because if he or she doesn't know how to operate the computer or the smartboard we won't be able to learn. =I think the teacher must know first because if she doesn't know it will be hard for us to find answers for example. =Yes because the computer , ICT require skills good skills.	L2caB L3caB L4caB
Do you think as a learner, you had more computer training skills before using ICT for Science?	-'No' said all learners. =No, You don't have to learn the computer. =No, because of those tablets, smartboards, they are like our smartphones. =Is the same as tablets have same as our smartphones. =No because if you check like cell phones or smartboards has papers with instructions on what to do maybe they say power on is which button, power off is which.	all L5caB L1caB L2caB L3caB
Learners like to discover things by themselves. How	-Most of the learners when they don't know some answers they don't go to the teacher and	L3caA

does technology impact on that?	ask for an explanation they google with their tablets if they are having them. -Eemm yah the learners do find the thing that is more than school properties because they use tablets as she has said and those which are much more important or interesting than our school. =Technology impact on that because it gives them ideas they can use on that project.	 L2caA L1caB
Learners use ICT largely for non-subject related activities.	-Sometimes they use them for, they can use them for unnecessary staff but at some point when the teacher tells us to open the books eeh most of the kids they listen to our teachers and they do the things teachers tell them to do, open the book go internet search about career search about thing you want to do and do the things that can help you to be successful in life. -True -They will play games while we are learning -Also watching videos. -And if you have access to the internet some google lyrics for certain music yes. -Some learners take pictures while the teacher is speaking. =Yes, they they sometimes they don't use tablets just to just to do the work that they gave them because children nowadays children like games and they like, they don't know what they gave what they gave, they don't know. =True because children want to catch-up like with stories like Skeem Saam so they don't watch them, so they watch them on tablets during school work.	L2caA all L7caA L3caA L2caA L3caA L6caB L3caB

	=Others they don't have cell phones so that they use that tablet to play that fun games and watch and watch funny videos. =Some other children can watch stories such as Skeem Saam , Scandal, and Generations. =Other children find those stories or funny games interesting more than school work so they will do that so they would do that than school work.	L5caB L2caB L1caB
When technology is used I understand better the natural science concepts than when books are used.	-Its true cause I do on my side understand better than when textbooks are used cause when seeing the life cycles as you said life, it teaches me and gives me much of impact information to use when writing a test or a class work. -Both actually because in textbook isn't it that we are reading what they are talking about the life cycle of the world is going in the smartboard they are showing us a video of how is growing in our world and they are teaching us more on our atmosphere,they are telling us how the world is polluted, they are telling us how the bottle, fish are dying in the sea,pollution eeh water pollution they say we have to save water and more and more staff. =True because on tablets if you check like any definition you can find it fully written than in textbooks. =If you, if you check on tablets it will give you more information maybe it will give you videos that you can watch to know what you are learning about than in textbooks because in textbooks they show just pics pictures = Tablets are better than a textbook because you can always watch videos about how you	L2caA L2caB L1caB L3caB L6caB

	are going to learn about this thing and how calculations are. =Eeh and its true because if you check on tablets history, you can see videos than when the teacher is telling you what happened to Hector Peterson, you cannot understand but if you watch videos you can understand.	L3caB

Teachers' questionnaires

Categories	Descriptions	Codes
It is important to use simulations and animations in teaching science since it facilitates learner 's acquisition of scientific processes and skills.	-Neither agree nor disagree. -Agree = Strongly agree.	TAcaA TBcaA TAcaB
ICT does help learners to acquire deeper understanding and insight of Natural Science in Grade 7.	-Agree. -Neither agree nor agree. = Strongly disagree.	TAcaA TBcaA TAcaB
I can use technology resources to facilitate higher order and complex thinking skills, including problem-solving.	-From videos of experiment, learners can formulate inquiry questions. -It encourages learners to think out of the box, and they are able to tackle broader subjects. =Learners are able to google the information using the internet.	TAcaA TBcaA TAcaB
The integration of ICT is supporting teaching and learning of Grade 7 Science.	-Animation, vidoes of practical activities that we do not have resources to do.	TAcaA

	-With the use of video and simulations. =Yes, with the use of videos and simulation.	TBcaA TAcaB
When ICT is integrated slow learners participate in discussions, make comments and sometimes take the lead in presentations.	-Yes. The learning and teaching end up being more teacher-centered because the teacher does the presentations. - Don't agree. They develop the attitude of hiding behind those who can more especially when it is group work. =Most of them do not even want to try anything. They have low self-esteem.	TAcaA TBcaA TAcaB

ICT coordinators' questionnaires

Categories	Descriptions	Codes
Can teachers and learners alone make it without expertise from technicians?	- No. They need technical assistance. = No, technical assistance is needed since ICT integration is new to most of the teachers, so expertise is needed for help.	CocaA CocaB
What type of ICT equipments do you use during Science period in your classroom**?**	- Smart board, teacher's laptop, and tablets. **=**Tablets, teacher's laptop, and smart boards	CocaA CocaB

Principals' questionnaires

Categories	Descriptions	Codes
What is your gender	-Male =Male	PricaA PricaB
What is your age group	-40 – 49 =50 – 59	PricaA PricaB

APPENDIX O: Objective 2

Results about the implementation of ICT in affecting performance and achievement levels of learners in Grade 7 Science.

Teachers' interviews

Categories	Description	Codes
Years of experience in teaching Science in grade 7.	-3 years -3 years =3 years	TAcaA TBcaA TAcaB
DoE ICT guideline policies for implementation of technology in teaching.	-Yes, Policy guideline was given to the school.The ICT policy was drafted out of that policy guideline. -Yes, there is a policy guideline that was given to the school. Our school used it to create its ICT policy. =Policy guideline was given to the school.The school used same policy guideline to draft and create ICT policy.	TAcaA TBcaA TAcaB
Implementation of technology in your class change the attitude of the learners in learning Science.	-Some learners become more interested whilst others shy away from learning. -They enjoy it because it is more relevant and it makes better to understand the concepts. = As I have said before, learners enjoy being taught by ICT. ICT also helps us because when learners watch video e.g of a growing plant their attention is drawn and they end up knowing exactly what is happening in the process.	TAcaA TBcaA TAcaB
Do you have enough ICT equipment for proper integration?	-Yes, Resources are enough for each and every learner. - Yes, Equipment are enough unless the problem of wifi and electricity which is above the school's power sometimes.	TAcaA TBcaA

	=Yes, the school has enough equipment even though the problem can be connectivity or electricity.	TAcaB
What type of ICT equipment do you use during Science period in your classroom?	-Smartboards and tablets. - Smart boards, laptop for the teacher, whiteboard and tablets. =Tablets for learners, laptops for teachers.	TAcaA TBcaA TAcaB
Changes you think ICT integration in Science teaching and learning has.	-Video plays an animation play vital role in enforcing most of the contents in Science. Learners tend to understand better when taught. -It is simple for the teacher to explain most of the content because videos are supporting the information given to the learner. =Most of content is simply because of the videos and animation.	TAcaA TBcaA TAcaB
Leadership's vision encourages every stakeholder to participate effectively in ICT.	-The leadership has the stakeholders buy-in by constantly involving them and having several workshops. - All the stakeholders involved are actively participating be it learner, teachers, and school community, they have adopted the project as their own. =Leadership involves stakeholders in each and every workshops or training concerning ICT to sell the ideas.	TAcaA TBcaA TAcaB

Observation

Categories	Descriptions	Codes
Is the learning objective clear and why the lesson in terms of skills, knowledge, and understanding of ICT?	- Learning objectives were clear, the teacher involved learners with questions and answers to introduce the lesson. Learners were asked questions about acids, bases and neutral but using examples that they daily use. -Yes, objectives were clearly stated. Skill knowledge and understanding of ICT were implemented by the teacher. = Learning objectives were clear. Only educators showed skills, knowledge, and understanding of ICT. The educator used a laptop, interactive smart board.	TAcaA TBcaA TAcaB
Which types of ICT resources the teacher use during lesson delivery, are they appropriate resources for the lesson?	-The teachers used a laptop, a smart board which was appropriate for the lesson. -Laptop and smart board. Yes, resources were appropriate for the lesson. = Laptop and smart board.	TAcaA TBcaA TAcaB
Does the teacher involve learners actively to use ICT effectively and creatively in other for learners to understand the content	-Learners were not involved to use ICT effectively and creatively but they were actively involved during an experiment where the teacher was demonstrating using litmus paper and learners were involved through questions and answers pertaining the experiment which was the reinforcement of awareness between acids, bases, and neutrals. -Learners were not actively involved to use ICT effectively and creativity to understand the content. Learners were actively involved in teacher demonstrations of using litmus papers	TAcaA TBcaA

	to check which substance is base, neutral or acid.It was good reinforcement of the content. = Learners were not involved in the used of ICT. The teacher was the one who was using a laptop and smart board to teach.	TAcaB

Learners' focus group

Categories	Descriptions	Codes
What impact do you think animations and simulations have on your grade 7 natural science ICT.	-Its because mostly Natural Science is after a long break in this instance when it's after a long break, we all tired because we ate kottas and whatever so the sound after each and every picture keeps us awake and it makes it much more interesting. = It makes you to imagine how the plant is growing and how and if it makes you to know more about the plants. =It makes you to concentrate because you can hear sounds like cucucucu like yaa like that. =It can make you feel curious about trees and other things.	L2caA L1caB L3caB L2caB
What impact does ICT professional training and development on the learners' performance?	=Our performance has improved like if we write a test like tomorrow, we can go and tell the teachers we can borrow the tablets and use to check the thing that we are going to learn tomorrow or about what the textbook show us. =To others the performance has improved because they are interested and others their performance dropped because if they do not understand in class they are not interested	L1caB L3caB

	they play games so they cannot be concentrated.	
How is the ICT technical support for teacher and learners for successful integration?	-Yes, there are people who whom are in charge of fixing our smartboard if they are jammed and charging our tablets.	L2caA
	=Yes because sometimes the smartboard is not working so that he connects something and the smartboard than the smartboard will work.	L3caA
	=Yes because if the teacher, no one is perfect everyone maybe X have this and Y have this they can connect that thing and it would work, so he can come and help our teacher so where she doesn't understand so that it can work up.	L5caB
	=Yes, because if teachers don't know how to fix the smartboard they can call IT guys then she can make things easier to learn.	L1caB
	=Yes because our teachers are not trained for ICT, so when we have IT ICT people to help us is better because they can teach our teachers about smart boards and tablets and what to do.	L6caB
	=If our teacher have a lot of work to do he can come and teach us IT in our tablets so that we can know more information than the one we have.	L3caB
	= Yes, an IT help us to know more about technology,eeh sometimes tablets are difficult so we can't find anything that we need so we call the IT to help us.	L2caB

Teachers' questionnaires

Categories	Descriptions	Codes
Gender.	-Female -Male =Female	TAcaA TBcaA TAcaB
Age group.	-20 – 29. -20 – 29 =50 – 59	TAcaA TBcaA TAcaB
Science teaching experience in the year(s).	-Between 2 – 5. -Between 2 – 5. =Between 15 – 20	TAcaA TBcaA TAcaB
Teachers with learner-centered pedagogical beliefs are successful in achieving high pass rates after integrating technology in Grade 7 Science.	-Neither agree nor disagree. -Strongly agree =Agree.	TAcaA TBcaA TAcaB
The Department of Education ICT Policies support the integration process within schools	-Agree. -Agree. = Strongly agree.	TAcaA TBcaA TAcaB
Teachers with high self-efficacy are more effective in supporting the learning of Grade 7 Science.	-Neither agree nor disagree. -Agree. =Agree.	TAcaA TBcaA TAcaB

What guidelines do educators need when integrating ICT in Grade 7 Science.	-From policy guideline form DoE. The school drafted ICT policy for educators. -There is a policy guideline that was given to the school by DoE. The school then drafted ICT policy from it that helps educators to refer when integrating ICT. =The need for ongoing training throughout is seen as an important tool in reaching and engaging teachers when integrating ICT.	TAcaA TBcaA TAcaB
Since you started using ICT do your learners in Grade 7 Natural Science achieve better pass rate than prior years.	-Most of the learners in the class I teach have improved a bit. -No, due to barriers that are encountered along the way, achievement is not up to standard. =Due to the barriers we having the achievement is not up to the satisfaction.	TAcaA TBcaA TAcaB
ICT performance indicators should be set up to help in assessing which initiatives are more likely to contribute towards a successful integration.	-Very true, that would help teachers in the integration of ICT successfully. -True. That would help us a lot and most of the educators would be much interested in using ICT. =Yes, that would give clarity to most of the educators who are still in need of support as	TAcaA TBcaA TAcaB

	far as ICT integration is concerned.	

ICT coordinators' questionnaires

Categories	Descriptions	Codes
How can adequate resources promote effective ICT integration?	- It's important for the school to be well equipped so that the learners can be able to use the technology to its fullest potential. = Well equipped school allows smooth teaching and learning. Coming to technology, it is workable if each and every learner is having their own tablet. Discipline is also simple because no one speaks to another person.	CocaA CocaB
Is there any problem with lack of ICT technical support in teachers and learners for successful integration.	- No, we are adequately capacitated as a school. = No, the school has enough technicians so educators are getting help anytime they want unless it is the issue with Wi-Fi or electricity.	CocaA CocaB
Is there a clear direction in DoE ICT guideline policies for implementation of technology in teaching.	- Yes, there is a policy, guideline given to schools on how to apply and create an ICT school policy. = Yes, policy guideline was given to the school. The policy explains clearly how to apply and draft schools ICT policy.	CocaA CocaB

Does leadership vision encourage every stakeholder to participate effectively in ICT integration?	-ICT integration is done across the board, managers are encouraged to embrace the use of technology in their management skills as well as capacitate their teachers to do so too. =Yes, ICT integration in education is one of 10 pillars that the MEC is encouraging the schools to apply successfully. Managers embrace ICT integration in our school and support is given to educators as for as is integration is involved.	CocaA CocaB
What type of changes do you think ICT integration in teaching and learning has**?**	-The learners are keen to learn. =It motivates most of the learners because of sound and videos rather than an ordinary way of teaching.	CocaA CocaB
How is the ICT technical support for teachers and learners results in successful integration?	- They don't have to waste time on technical challenges which waste technical time. =If they are technical challenges, teachers know who to contact for help.	CocaA CocaB
How does leadership's vision encourage every stakeholder to participate effectively in ICT integration?	- When the school head and SMT embrace the vision, it's easier to filter it down to rest of the staff. **=**The leadership's vision includes ICT integration and	CocaA CocaB

	make sure that is correct in the school by monitoring the implementation. It becomes simple to sell the idea to stakeholders.	
Do technicians assist teachers and other stakeholders in keeping the ICT pedagogical processes on the place?	-Yes, technicians to make sure the teaching is not hindered by technical issues. The SMT by encouraging and finding ways to integrate lessons which ICT. =Yes, as the school we scarcely experience where technical challenges become a hindrance for teaching and learning	CocaA CocaB

Principals' questionnaires

Categories	Descriptions	Codes
Indicate when did Paperless classroom project start in your school	-2 – 5 years =2 – 5 years	PricaA PricaB
GDE's vision encourages every stakeholder to participate effectively in ICT integration?	-Strongly agree. = Strongly agree.	PricaA PricaB
SGB and SMT support and encourage every stakeholder to participate effectively in ICT integration	-Strongly agree. =Agree.	PricaA PricaB
There is a clear direction on DoE ICT guideline policies for implementation of technology in teaching?	-Strongly agree.	PricaA

	=Agree.	PricaB
There are problems of lack of ICT technical support to teachers and learners for successful integration	- Agree. =Disagree.	PricaA PricaB
Teachers with learner-centered pedagogical beliefs are successful in achieving high pass rates after integrating ICT	- Strongly agree. =Agree.	PricaA PricaB
Teachers with high self-efficacy are more in the integration of ICT in teaching.	- Strongly agree. =Agree.	PricaA PricaB
Teachers are motivated and rewarded to encourage the integration of ICT.	-Agree. =Agree.	PricaA PricaB

APPENDIX P: Objective 3

Results about the attitudes of educators and learners with the integration of ICT.

Teachers' interviews

Categories	Description	Codes
According to your own understanding is there a need for ICT integration in learning of Science in school?	-Yes, ICT integration makes teaching some concepts easy that we don't have teaching aids for. -Yes, It makes learning more easier with teaching aids used in class.They enhance the delivery of content. =Yes, I can see that since ICT has been integrated learners I taught before. It is because of videos and animation, that sound makes them to concentrate.	TAcaA TBcaA TAcaB
Do you think ICT integration in Science teaching can support learning in schools?	-Yes, sometimes videos and games can facilitate support. -Absolutely, being able to use several apps to explain a concept makes it easier. =Definitely, videos and animations help us a lot. Science is full of experiments of which even if the school does not have resources, videos help a lot to close the gap.	TAcaA TBcaA TAcaB

Observation

Educators have a positive attitude towards ICT integration. They have some few things they wish could be rectified by Department of Education in other for them to use resources successfully.

Learners' focus group

Categories	Descriptions	Codes
Technology is helping learners become innovative in the classroom as compared to conventional teaching and learning.	-No, because of these days ah.. in classes, in smart boards there is picture ah… videos that can show us more learners about NS subject, before it was hard because they were supposed to have pictures, videos they were supposed to take you see, what do they call it, what is that thing of yours of playing the video. They were supposed to put charts for pictures. Now in smart boards, they can use simple and fast, we can use our tablets to research about our subject and things we want to do when we grow up and staff.	L1caA
	-I don't think its useful because ah… sometimes our smart boards and tablets depend on electricity if we do not have electricity we can do things that we usually do with electricity using our smart boards.	L2caA
	=I think technology helps us because at old times our teachers will give us textbooks and there was not enough information in the textbook and we can use the tablets to search for the research.	L1caB
	=Mhh I think it is better because nowadays we use ours tablets they help us to research more about school things ahhhh things stuff like that.	L2caB
	=And I also believe that our performance has improved because of the use of tablets because we can search like home works on the internet or things that our teacher tells us to search.	L1caB

What are your perceptions about the recently integrated ICT in Grade 7 Science?	-It is good because ah… in our school, we do not have textbooks. They gave us tablets or they show us on the smart board how the plant's animals and the biosphere, hydrosphere walks you see gravity and staff and so much more.	L2caA
	- Am. I think sometimes it is bad because we we use tablets and rely on connection sometimes the wifi is low so we gonna be interrupted and we don't have enough textbooks.	L2caB
	-Eeh It is good because we get to see natural disasters life instead of seeing them in pictures and charts.	L3caA
	=Is good because we can always search what we don't understand.	L6caB
	=Is good because we don't need to search things that we are not sure if it's in the textbook.	L1caB
	=Is good because we don't need to carry a lot of books	L2caB
	=Its sometimes good because we search words that we don't understand.	L7caB
	=We use it because it helps us to have good knowledge	L4caB
	=Is good because our teachers cannot explain us exact things that the textbook says but the tablets or ICT we can search things better.	L3caB
When ICT is used there is an improvement in learners attitude on the content of the subject	-It's true because sometimes when the teacher always speaks and does not show us videos and pictures on the smart board we get bored and talk to other learners so if the teacher get to switch on the smart board and	L4caA

	make pictures and write on the board we get attracted and look at the teacher and attend. =Its true = It's true because if we can't calculate we just use our tablets, laptops, smart boards and there are a calculator. =Yes is true because in when we learn maths laptops, smart boards and tablets help us to solve problems. =I think is true because we can learn more about Natural science and animals	most L6caB L4caB L2caB
Can technology distract you from learning	-Yes because some other learners might make you lose theee concentration foo because they would be doing something interesting the more interesting than what you are learning. - And also like we want unnecessary things but those that are necessary we don't take them serious =Yes because sometimes if they give us tablets there are some who go to youtube and watch naught videos. =Yes because games just notify you and you want to download them, yes so you download them =No, because other learners don't concentrate on their work they are busy with tablets. =No, because technology can help us a lot in the class because our teachers can tell us do this and then you find it interesting and you do it.	L2caA L3caA L4caB L6caB L3caB L1caB

Teachers' questionnaires

Categories	Descriptions	Codes
ICT in Science for Grade 7 is an unnecessary addition to our work and in some cases even an obstacle in teaching.	-Agree. -Disagree =Strongly disagree.	TAcaA TBcaA TAcaB
Slow adoption of ICT in Grade 7 Science can be attributed to plain reluctance and aversion to technology and faith in the old-fashioned method of teaching.	-Strongly disagree. -Agree. =Agree	TAcaA TBcaA TAcaB
Working with ICT in the classroom is something that overwhelms me.	-Neither agree nor disagree. -Disagree = Strongly disagree.	TAcaA TBcaA TAcaB
Teachers receive salary incentives to encourage implementation and use of ICT in Natural Science.	-Not that I know of. -No, they don't. We get our normal salaries only. =No, we get our normal salaries.	TAcaA TBcaA TAcaB
Learners are more motivated when using ICT.	-Yes because of videos and 3D pictures. -They watch videos of that particular lesson and understand better. =Yes, they enjoy videos while they learn at the same time.	TAcaA TBcaA TAcaB
I am content with the traditional way of teaching.	-Yes and no.The traditional way of teaching still required that we do practicals and we	TAcaA

	have a more hands-on lesson. -No, I am not. As long as more training can be done on the simple ways of using ICT for planning and teaching I would be more motivated in using ICT. =I am happy with the recent way of teaching using ICT.	TBcaA TAcaB
The integration of ICT in Grade 7 Science motivates and focuses students who show low interest in schoolwork.	-I think those who show low interest even more because they are left behind, the most performing learners are the ones who show more interest and ask a question. -The learners are enjoying the lesson more. =Some are enjoying the lessons because of the videos.	TAcaA TBcaA TAcaB

ICT coordinators' questionnaires

Categories	Descriptions	Codes
According to your own understanding is there a need for ICT integration in learning?	- Yes. It's easier for learners to grasp the concept because they can be made live by usage of videos and 3D visual reality. = Yes, ICT allows videos and 3D visuals. Learner becomes in a better	CocaA CocaB

	position to understanding most of the concepts because of the view the reality of what is happening rather than information being explained to them.	
How does the implementation of technology in your school change the attitude of the learners in learning Science?	-They enjoy and they excited about learning. =Learners are excited and they are willing to learn more. Teachers are supposed to have close look at what learners are doing with their tablets because they might end up doing their things out of the lesson.	CocaA CocaB

Principals' questionnaires

Categories	Descriptions	Codes
ICT is an unnecessary addition to our school and in some cases even an obstacle in teaching.	-Strongly disagree. = Strongly disagree.	PricaA PricaB
ICT does help learners to acquire deeper understanding and insight of learning.	- Strongly agree. = Strongly agree.	PricaA PricaB
Teachers complain a lot of not having enough time to	-Disagree.	PricaA

integrate ICT in their teaching.	=Disagree.	PricaB
ICT is an unnecessary addition to our school and in some cases even an obstacle in teaching.	-No.Teachers realize the benefit of ICT. They innovate and adapt their teaching well. =No. ICT integration is accepted as a tool that will advance teaching and learning.	PricaA PricaB

APPENDIX Q: Objective 4

Results on the challenges encountered during the integration of ICT in the learning and teaching of Science.

Teachers' interviews

Categories	Description	Codes
The problems or limitations which you have identified with the use of ICT as a teaching	-Electricity supply, It takes time to plan and sometimes videos are not clear. -Time constraints. WIFI sometimes is down and if there is no electricity. =WIFI becomes down sometimes when there is no electricity and smart boards jam sometimes.	TAcaA TBcaA TAcaB

Observation

Categories	Descriptions	Codes
What problems or limitations have you identified in the use of ICT in teaching and learning?	- Learners were not given any chance of using ICT, no tablets were used in class. - Tablets were not given to the learner for active usage of ICT during the lesson. Only the teacher used ICT resources during the lesson. =Learners are not fully involved in using ICT resources during the lesson. The tablets were not given to the learners. The reasons that were given by the teacher were that they are a problem of connection, they are afraid that learners might steal tablets, at the present moments most of the learners are computer illiterate. They find themselves spending much time teaching a computer than teaching the content. The teacher complained about Wi-Fi connection which is a challenge. When they are off-line it means they must use old ways of teaching and learning.	TAcaA TBcaA TAcaB

Learners' focus group

Categories	Descriptions	Codes
What are the problems or limitations which you have identified with the use of ICT as a teaching model?	-The limitations we get obviously its electricity when the power of is off and when batteries are low and when the smart board's jam and the Wi-Fi connection is not on. =If the Wi-Fi is on and other people are using it for something else. It can show that thing on you and then download itself. =Eeh the challenges that we have is that like tablets or smart boards just freeze yes. =Eeh some tablets when you are using them they just install happy games and funny videos by themselves. =Sometimes our tablets are freezing and Wi-Fi is not connected. =Sometimes electricity runs out so we cannot use them.	L2caA L1caB L3caB L4caB L5caB L1caB

Teachers' questionnaires

Categories	Descriptions	Codes
Teachers do not have enough time to integrate ICT in their teaching.	-Neither agree nor disagree.	TAcaA

	-Neither agree nor agree. =Disagree	TBcaA TAcaB
Challenges/barriers to integration undermine the successful implementation of Natural Science in Grade 7.	-Agree. -Strongly agree. =Disagree	TAcaA TBcaA TAcaB
Barriers that Natural Science teachers face are the absence of motivation and reward system to encourage the use of ICT.	-Disagree. -Agree. = Strongly disagree	TAcaA TBcaA TAcaB
What are some of the constraints to using ICT in your teaching Natural Science in Grade 7?	-Takes time to do planning. -Time factor. Sometimes Wi-Fi is down or smart boards are not working, we need to use whiteboards for writing. =Encounting problems with Wi-Fi and touch screen of the smart board.	TAcaA TBcaA TAcaB
What are the learners' challenges during ICT integration in Grade 7 Natural Science?	-After sometimes learners get used to videos and get bored instead of stimulated. -Wi-Fi connectivity. Electricity cut off. =Some of learners' tablets do not have e-books and some refuse to function properly.	TAcaA TBcaA TAcaB

Principals' questionnaires

Categories	Descriptions	Codes
Lack of training of educators or ICT skills in the use of ICT hampers successful integration.	-Little or no training will leave teachers at level one of the ICT use. More training will help them innovate and adapt even further. = Yes, the training was not enough hence most of the teachers are computer illiterate so a little bit more of training is needed for smooth implementation of ICT.	PricaA PricaB
What are the problems or limitations which were identified with the use of ICT as a teaching model your school as far as you know?	-Learner training time was little. Techno Sarvy teachers were few. We had to put many hours to train both. =Enough training for both teachers and learners.	PricaA PricaB

APPENDIX R: Objective 5

Results of recommendations to improve the use of ICT in teaching and learning of Science.

Teachers' interviews

Categories	Description	Codes
Recommendations to make in order to address the problems.	-The school can a generator and as teachers, we should still do practicals. - Sometimes the ATP (annual teaching plan) make it hard to experiment a lot with technology. =For electricity the school can organize generator for in case there with no electricity.	TAcaA TBcaA TAcaB

Observations

Continuous training is still needed for some educators to use ICT resources with confidence. The school needs to have a generator for in case of electricity cut off. The whiteboard is needed for the teachers to write on in case the Wi-fi is giving the problems.

Learners' focus group

Categories	Descriptions	Codes
What recommendations would you like to make to address the problems?	-I think what solution we can have in our school is have a generator that will generate the smart boards that can help us to learn to help us our teachers to learn to teach us and in a lab, they can use also generators to charge our tablets when ah.. when the electricity is gone. The telecom they should tell our school when the electricity is gone and they can know eeh the electricity it is gone and they can use the generator to generate our smart boards. -I think they could use the solar system. Energy source =I think if we tell our teacher and she tells the principal, they would find something creative that if the electricity is off we can use the Wi-Fi.	L2caA L2caA L1caB L3caB

	= I think the school can use generation generator so that we can have a backup.	

Teachers' questionnaires

Categories	Descriptions	Codes
Lack of training and education in the use of ICT hampers successful integration.	-Training of teachers is really needed and it must be continuously like workshops of any other subjects. -Teachers are adamant about using it. More training is needed for teachers to integrate ICT properly. =As teachers, we need training so that we can be able to use ICT for better education of our learners.	TAcaA TBcaA TAcaB

Principals' questionnaires

Categories	Descriptions	Codes
What recommendations would you like to make to address the problems/limitations?	-Pre-training before the rollout. Creation of a sustainable teacher support programme. Creation of magnet teams to aid effectiveness = GDE should appoint qualified technical assistance to help maintain and repair faulty gadgets. Lack of efficient technical support frustrate the teachers and this will result in them losing confidence in ICT.	PricaA PricaB