EXPLORING THE PEDAGOGICAL VALUE OF USING SMARTBOARDS AND TABLETS IN HIGH SCHOOL PHYSICAL SCIENCE CLASSROOMS

BY

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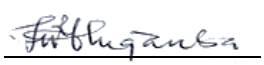
Declaration

I declare that Exploring the Pedagogical Value of Using Smartboards and Tablets in High School Physical Science Classrooms is my work. I also declare that sources and all information I have used or quoted have been presented according to the academic rules and ethical conduct. I have fully cited and referenced all material and results that are not original to this work.



SIGNATURE

24 March 2021

DATE

Acknowledgments

First and foremost, I thank the Lord Almighty for giving me the strength, knowledge, opportunity, and ability to undertake this research and to persevere through all these years so that today I can stand proudly with my head held high. It was a challenging experience, particularly when we were faced with the emergence of COVID 19. It disrupted a lot of set out programs and closure of schools which was the source of my data. However, through the hand of God, His love and desire manifested, amen.

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Abstract

In an attempt to improve the quality of education, the Department of Education installed Smartboards and gave Tablets to learners in selected township schools. These gadgets have now been used as instructional tools to enhance the understanding of abstract concepts and improve the quality of lesson delivery. This research study was conducted to find out if there is any pedagogical value in the use of these technologies in the teaching and learning of Physical Science. The study was carried out in two secondary schools, targeting one grade 12 teacher per school that used Smartboards and Tablets from 2015 to 2020 for teaching and learning. Data was collected through lesson observations and teacher interviews to understand how these teachers and their learners manipulate these technologies in Physical Science. The data was analyzed using a multi-level thematic process of coding to investigate relationships, differences, and similarities. Results have shown that teachers have developed a great enthusiasm for using these two technologies forteaching and learning. Also, there is considerable improvement in the level of understanding of the abstract concepts by learners in the focused subject.

Key words: *Smartboards, Tablets, ICT Pedagogical value, Physical Science.*

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List of Abbreviations

CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
NCS	National Curriculum Statement
PhET	Physics Education Technology
TCC	Teacher Communication Cycle
TCC	Teacher Communication Cycle
TMC	Teacher Modelling Cycle
TPC	Teacher Practice Cycle

Chapter One

INTRODUCTION AND BACKGROUND

1.1 Introduction

Digital technology is fast making inroads in the teaching and learning of school curricula across the world. Taking the direct input of Jensen (2018, p.1) regarding the importance of technology in education, "it is evident that the world is becoming more and more digitalized, and schools are no exception". Grimus and Ebner, (2015) also stress that it is logical to admit that in the present time, teachers and learners require prospects that simplify the process of teaching and learning. In response to these developments, Smartboards were installed and Tablets offered to learners in 368 schools in the Gauteng Province in South Africa (iTWeb, 2016). In order to redress existing inequalities in education, the majority of schools participating in this program were from underprivileged communities (Graham, Stolls and Kapp, 2020). The silent question in all these developments is: 'Does the use of these gadgets improve teaching and learning?"

In an endeavour to try and respond to the query, this research examined the use of Smartboards and Tablets in the teaching of Physical Science in two schools in Johannesburg. Physical Science is a critical subject in the South African school curricula because it is valued highly in the advancement of critical job opportunities needed in the economic industry.

Physical Science's pass rate in South Africa has received attention because of the nature and value attached to its connection to the job market and training of scarce skills. In agreement with the Department of Education (2015), the drop in the pass rate for Physical Science at the Matric level has been of great concern to the sector. Over time, the Department has sought factors contributing to this decline.

In trying to address some of the challenges relating to quality, effectiveness, and efficiency in teaching and learning fraternities, the government introduced "ICT in education" as one of the ten important strategic pillars of the "Ten Pillar Education Plan from 2014 - 2020" (Department of Basic Education, 2018). This ten-pillar program aims to eradicate social, economic, and spatial legacies through radical Transformation, Modernisation, and Reindustrialisation (TMR). The matriculation pass rate of Physical Science has been on a fluctuating trend from 2015 to 2018 regardless of the introduction of digital technologies particularly in Physical

Science classrooms. However, 2018 registered an improvement which was credited "to the stability in the curriculum and both teachers and candidates becoming familiar with the assessment style of the subject." (DEE, 2020, p.47). Despite this slight increase, the government acknowledges that there is more to be done to continue improving the results. In response to this recognition, this study sought to investigate if Smartboards and Tablets given to schools could be adding value to the teaching and learning of Physical Science, thus contributing to the improvement of the pass rate?

1.2 Research Purpose Statement

This research aimed to investigate the pedagogical value of the use of Smartboards and Tablet computers in the teaching and learning of Physical Science in selected South African classrooms. In essence, the research sought to determine how Smartboards and Tablets are used in teaching and learning in the context of two Physical Science classrooms (one from each of the two schools targeted).

1.3 Research Problem Statement

While the adoption of Smartboards and Tablets in schools in South Africa has received much endorsement from the government, what needs to be established is the pedagogical value of these teaching aids. Moreover, there is limited published literature by the department of education that qualitatively highlights the impact of Smartboards and Tablet computers in enhancing teaching and learning. However, in his study, Tshelane (2017) posits that teachers are instrumental in ensuring that there is a successful implementation of ICT tools for curriculum delivery. Vandeyar (2015) agrees with this assertion by emphasizing that teachers as curriculum designers enact practices that are aligned to the Curriculum and Assessment Policy Statement (CAPS) (2011) and the National Education Policy Act (27 of 1996) complement.

The role played by teachers and principals in the implementation process, determines the successful integration in the classroom. Despite the recent presence of ICTs in the classroom, the teacher as the principal designer of learning materials seldom enacts policies to complement the use of modern tools of technology (Tshelane, 2017). On the same note, Coetzee (2012)

expresses the inability of the policies to afford customised guidance for the ordinary South African classroom, especially to student teachers, making the implementation of ICT policies impossible especially in institutions that have limited digital resources. Vandeyar (2015) eludes to the fact that teachers negate ICT implementation owing to a lack of clarity regarding the e-Education policy. Also, Ndlovu (2015) asserts that policies' failure to make explicit the contribution of ICTs in the teaching and learning process appears to be responsible for the teachers' struggle to align their integration to the standards suggested by the policy. In addition, some studies indicate that both pre and in-service teachers are not adequately prepared for the use of the modern technologies available in their classrooms, this has created a gap in the effective implementation of this intervention (Koc & Bakir, 2010; Fook, Sidhu, Shah, & Aziz, 2011; Livingstone, 2015). It is for that reason that this research sought to establish the return on investment by investigating the benefits of the use of the two digital technologies in Physical Science classrooms. As a result, the following research questions were identified;

Main Research Question

How does the use of Smartboards and Tablet computers bring value to the teaching and learning of Physical Science at Further Education and Training Level?

The Secondary Research Questions

1. What are teacher's perceptions on the pedagogical value of Smartboards and Tablet computers in Physical Science classrooms?
2. What are teachers' enacted practices in the use of Smartboards and Tablet computers for teaching Physical Sciences?
3. How does the use of Smartboards and Tablet computers enhance teaching and learning in high school Physical Science classes?

1.4 Research Objectives

This research intended to explore the pedagogical value of Tablets and Smart Board Technology as teaching and learning aids in the teaching and learning of FET Physical Science. The secondary objectives were outlined as;

1. To determine the teachers' perceptions on the pedagogical value of Smartboards and Tablet computer use for teaching and learning FET Physical Science.

2. To determine the teacher's enacted practices regarding the use of Smartboard and Tablets computers in teaching Physical Science.
3. To establish how the use of Smartboards and Tablet computers enhance teaching and learning in FET Physical Science classrooms.

1.5 Significance and Purpose of the Study

Based on the above questions, this research fills the literature gap on the pedagogical value that Smartboards and Tablet computers can afford to teaching and learning. Furthermore, the research gives an insight to the education sector's stakeholders, sponsors, policymakers and the government in terms of the viability of Smartboards and Tablets in teaching and learning. This research also derives its meaning from advancing students' learning of Physical Science, the advancement of teaching as a discourse, and aligning it to national policy frameworks on education.

1.6 Preliminary Literature Review

The following literature review sought to unveil the fundamental role of previous research and publications, that reinforce the argument for digital learning to achieve the main objective of this research (Master, Kent, & Ph, 2008; Pilcher, 2018). In essence, it helped to define and clarify the key concepts that would be applied in the development and clarification of this study's conceptual framework.

1.6.1 Importance of Smartboards and Tablets to learning

This research intended to uncover how Tablet and Smartboard computers could be effective in translating the students' abstract concepts into tangible conceptions in Physical Science Education as variously noted by Saraya (2009), Kasot & Soykan (2017) and Santisteban, 2017). The cognitive fundamentals for Physical Sciences learning involve scientific as well as analytical thinking. Thus, learners require mathematical and problem-solving skills to cope with the subject. A study by Yapici and Karakoyun (2016) concludes that the use of Smartboard and other digital learning aids in Biology classes permits students to self-reflect easily and to quickly understand the subject content. Since Physical Science and Biology deal with the

practical application of knowledge and skills through experimentation, this research thus sought to ascertain the extent to which Yapici and Karakoyun's (2016) assertion is also applicable to Physical Science students.

Furthermore, a study conducted in the science environment on the attitudes of high school students towards Smartboards in learning Biology by Yapici and Karakoyun (2016) (2016) suggests that students have a significantly positive attitude towards the use of Smartboards in Biology classes. Similarly, research conducted by Ferguseon (2001) on the contribution of information and technology in education concludes that Tablets have the potential to strengthen the capability of learners in problem-solving processes. In view of this, this study thus sought to ascertain the veracity of these findings in Physical Science.

1.6.2 Importance of Smartboards and Tablets to teaching and learning

Teachers as curriculum developers and implementers of ICT policies benefit greatly from the affordances of Tablet computers and Smartboard technologies. Studies by Stoica, Paragina, Paragina, Miron, & Jipa (2011), Yapici and Karakoyun (2016) and Pruet et al. (2016) have found out that in terms of curriculum design, teachers can easily prepare content that integrates audio, record presentations of lessons, thus, affording learners the opportunity to replay, and save for later use. Similarly, Kasot and Soykan (2017) also point to the fact that Tablets enrich the quality of the teachers' expression of important complex terms relating to the subject. In light of these findings, this research thus intended to determine how, since Physical Science is such a challenging subject, the teacher can retrieve crucial information to explain abstract concepts through the use of Tablet computers and Smartboards.

The study by Enriquez (2010) highlights some of the potential benefits offered by Smartboards, such as improved performance, increased attentiveness, as well as an improved ability to organise class material ad hoc during class delivery. Jensen (2018) further asserts that Smartboards are important tools that reduce learning time, motivate students through visual elements, affording individual assessments, and self and peer feedback during content delivery. Thus, this study focused on gauging the applicability of these findings in the teaching and learning experience of Physical Science.

1.6.3 The role of teachers in the use of Smartboards and Tablets

Research conducted by Šumak and Šorgo (2016) on "acceptance and use of interactive white-boards among teachers" posits that the attitude of teachers and the teaching environment have a significant impact on how teachers perceive the pedagogical importance of ICT integration. In view of this assertion, this research thus examined how the role of teachers and their readiness to adopt Tablets and Smartboards as teaching tools influence the success of these digital teaching aids. While, as MacDougall & Squires (1997) explain, the principal has the responsibility of initiating professional development programs for ICT integration, teachers have the role of seeking professional growth in terms of the ICT skills, familiarity with special applications, integration of ICT into existing curricula, and changing the curricula related to the use of IT for the benefit of learning. It is in this context that this research acknowledged that teachers should be prepared to use technology to communicate to students, show learners the advantages it brings, and know how the technology supports the teaching process. Thus, after identifying the importance of Smartboards and the roles of teachers in ICT integration, it was also important to look into the value proposition of Smartboards and Tablets from the lenses of visual literacy.

1.6.4 Dale`s cone of literacy (visual literacy)

Stokes (2002, p.10) defines visual literacy as "the ability to interpret images as well as to generate images for communicating ideas and concepts". Based on Dale`s cone of literacy, visual literacy paves the way for verbal literacy in human learning. As a result, it is logical to acknowledge that visual learning is an elementary building block and foundation of the learning processes (Sinatra, 1986). Also, Berger (1972, p7) explains, "The child looks and recognizes before it can speak". For that reason, it is generally understood that the Smartboard and Tablet computer has a wide range of functionalities that offer visual, auditory, and writing tools that permit learning through interaction with other devices, during group discussions. This research thus intended to determine how applicable this is in the use of Smartboards and Tablets in the teaching and learning of Physical Science.

1.7 The Significance of Educational Policies in ICT Integration

Curriculum and Assessment Policy Statement (CAPS) is one of the most instrumental educational policies. It is a revision of the previous National Curriculum Statement (NCS) (DBE, 2014). CAPS gives teachers detailed guidelines of what to teach and assess on a grade-by-grade and subject-by-subject basis (DBE, 2014). With the CAPS document for Physical

Sciences curriculum, it is expected that Physical Sciences teachers provide examples of the types and standards of school-based assessment tasks that would be appropriate for their learners, and provide material that will assist them in the preparation for the National Senior Certificate examinations. In addition to the CAPS document, the White Paper on e-Education (2004) is also another key policy that is meant to direct efforts aimed at transforming learning and teaching towards effective teaching and meaningful learning through ICT. In principle, it directly addresses the integration of ICTs into the curriculum. For this research, the White Paper on e-Education was analysed in detail specifically in the section that provides guidance on how ICTs should be used in the classroom by both teachers and learners to achieve the national curriculum goals. This was conducted in the context of teaching Physical Science. Furthermore, a check on the policy documents (CAPS Document) was made to closely understand the government's position regarding the integration of ICTs in the teaching and learning of Physical Science.

1.8 Preliminary Theoretical Review

The theoretical review of literature borrows the ideas of philosophers to help model the research and understand the antecedents embedded in the research (Gardner, Cogliser, Davis, & Dickens, 2011). These theories also assist in organising and choosing the appropriate literature to link to the research. For this research, ideas from Laurillard's (2002) conversational framework were used as a lens in answering the research questions. According to Ndlovu (2015, p.25), engaging Laurillard's ideas help to expose "what is of pedagogical value in the integration of ICTs into subject teaching" in any given learning experience.

1.9 The Conversational Framework

This conversational framework is the brainchild of Laurillard (2012, p.11), which brings out the issue of dialogue orchestrated between the teacher and learners. According to Laurillaurd (2012, p.11), the framework seeks to "evaluate the extent to which the various media support the full specification or pedagogical setup". Furthermore, Laurillard asserts that teachers' use of digital technologies increases learners' opportunities for interaction and offers a wider variety of affordances, as compared to more conservative scholastic methods, thus increasing students' motivation to produce quality collective outputs. For this reason, this research

adopted Laurillard's Conversational Framework. It offers teachers a structure that can enable them to effectively incorporate technology into the teaching and learning process. The following flow diagram outlines a summarized version of how a learning process can be traced through the Conversational Framework.

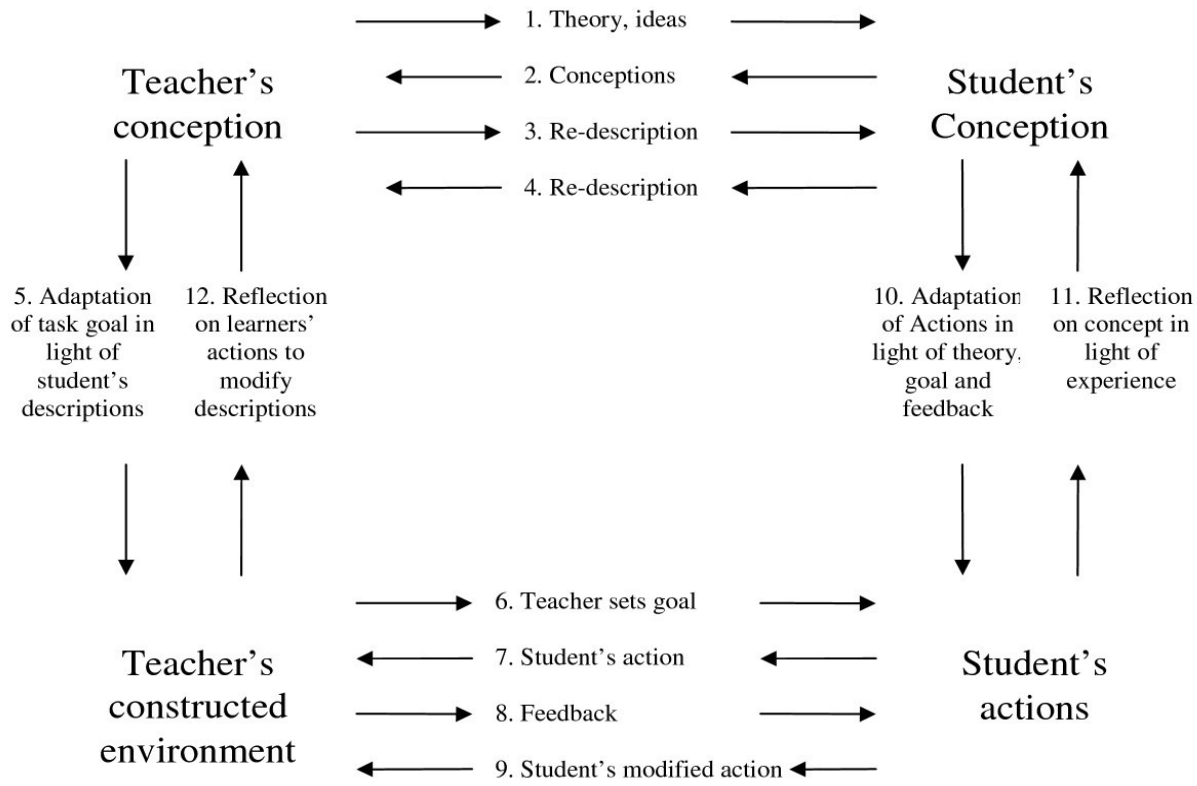

Figure 1.1: The Conversational Framework (Laurillard 2002, p. 87)

The Conversational Framework provides a unique way of explaining the act of teaching based on five key events: acquisition; discovery; dialogue; practice and creation" (Laurillard, 1993). These key events described in conversation learning methods are identified as; learning through acquisition (from lectures and books), learning through practice (tasks completion), learning through discussion (in scenarios), and learning through discovery (on field trips and through the practical application).

In this conversational framework, the learning process takes place through a series of activities by teacher and learners at the level of establishing the topic and describing learning goals, which is "describing and re-describing each participant's conception of it, this signifies the discursive process Furthermore, the adaptive process represents the action of the teachers and learners as they change their actions at the task level, considering the discursive process evident at the description level Thirdly, the interactive process is a task-level environment, where teachers and learners strive to achieve learning or task goals Learners providing feedback, then the teachers act on learner's feedback in light of the task goals. Finally, the reflective process is a task-level interaction progression that applies internally to teacher and learners Teachers

and learners reflect on the task level interaction to re-describe their conceptions in light of the topic goals (Laurillard, 2002, p.86).

The conversational framework fits well with teaching Physical Science since the lessons are learner-centered and allow for active learner participation (Laurillard, 2012, p.92). The framework also supports the notion that the mobility of digital technologies creates interesting prospects for innovative methods of learning. The mobility of digital technologies transforms the nature of the physical relationships teachers and learners have as well as the objects of learning (learning materials, learning environment and peers). The framework suggests that learning is not an action imposed on students, but rather a means of mediating their learning iteratively and interactively (Laurillard, 1999). Teacher-learner dialogue, as well as peer-dialogue, has the paramount latent to support learners in reflecting and understanding their learning (Laurillard, 2012). With the Tablets, learners can consolidate and share information if their understanding is in sync.

1.10 Conceptual Framework

This study aimed at understanding how Smartboard and Tablet computers could be used as important ICT tools to improve teaching and learning.

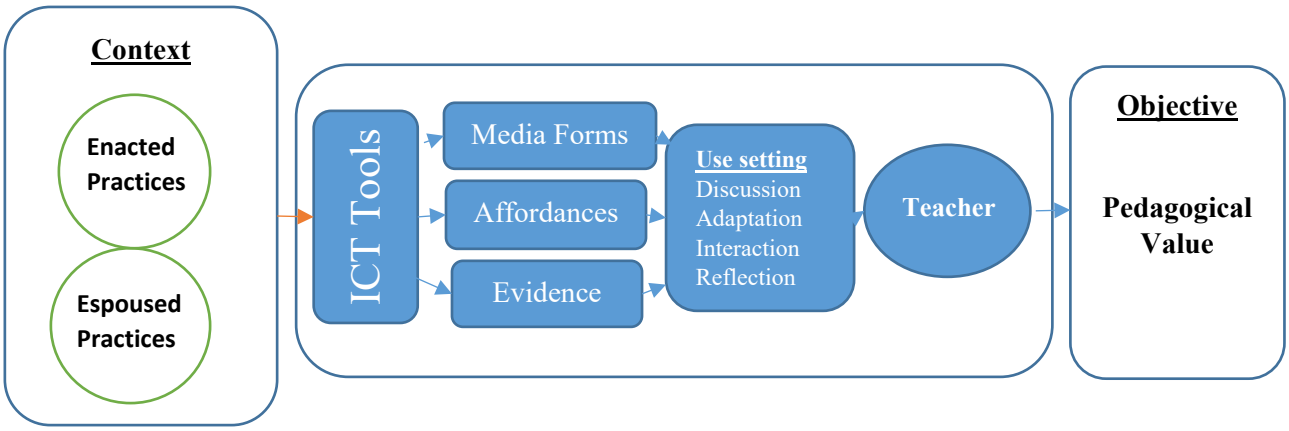

Figure 1.2: Conceptual Framework

The illustration above demonstrates the pathway this study took to ensure objectives were achieved. In principle, this Conceptual Framework helped identify that which is of pedagogical value and that which is not, in terms of the use of Smartboards and Tablets by Physical Science teachers from the two selected schools. The analysis began with the understanding of the

relationship between espoused or adopted practices and teacher enacted practices to establish how they lead to providing impetus of the pedagogical value of Smartboards and Tablets. Thus, looking into teacher beliefs and how they influence their actual teaching with these ICT tools. The teacher`s adoption of specific practices is also dependant on his/her decision on how to engage the media forms and their affordances. Teachers as curriculum designers enact practices that are aligned to the policy, which informs their enacted practice. What they consider to be of pedagogical value determined the characteristics of the user setting or pedagogical setup. In essence, the pedagogical setup consists of four types of activities; "*discussion*" between teacher and student. "*adaptation*" of student actions and the teacher's built environment, "*interaction*" between the student and the learning setting defined by the teacher, and "*reflection*" of student performance by the teacher and student Laurillard (2002). When different types of ICTs are used effectively, they promote learning.

1.10.1 Media Forms embedded in Tablets and Smartboards

Romiszowski (1988: p8) describes media as "carriers of messages, from some transmitting source to the receiver of the message". Media forms refer to technological means and channels by which the media is created, produced, circulated, used, and read (Noor-Ul-Amin, 2013). In essence, media forms include; productive, communicative, narrative, interactive, and adaptive media. Close examples of media forms can be moving images like film, television, video, and animation. These moving images provide different levels of support for various kinds of learning experiences (Petko, 2012; Venkatesh, Croteau, & Rabah, 2014). In essence, the media forms brought about by technological fruitions transform pedagogy, which Wang et al. (2010) explain as the teaching strategies, techniques, or methodologies that instructors use to facilitate teaching and learning.

Tablets can assist with communicative media, which enables the exchange of information between teachers and learners and amongst learners (Treem & Leonardi, 2012). Communicative media are integral and can support conversations which is critical for descriptions, debate, reflection, feedback, and goals. Smartboards significantly enable the delivery of narrative media forms, which are non-interactive and usually used to present subject content structure (Laurillard, 2002). In this case, the user is just the observer of information. Unlike the interactive affordances, Laurillard (2002:126) suggests that adaptive media enables learners to learn from using "the modelling capability of computer". Furthermore, Laurillard's (2002:107) description of interactive media emphasized the importance of influencing the pace at which students learn, that is through the feedback of the content taught. The productive

media are technologies or applications that Tablets and Smartboards can handle that could be used by learners to articulate their conceptions. After identifying these important media forms and the associated affordances as suggested in the literature, the research proposed a research methodology that assisted in the discovery of the potential value proposition of Tablets and Smartboards as learning aids in the subject, Physical Science.

1.10.2 Affordances of Tablets and Smartboards

According to Gibson (1979) as cited in Wang et al. (2010, p.70), "affordances are actionable properties that exist between an object and an actor". Equally, with Physical Science teaching and learning, pedagogical affordances of Tablets and Smartboards can be defined as those characteristics of Tablets and Smartboards that determine whether a specific learning activity can be implemented in the subject. In this study, affordances are identified in line with Conole and Dyke's (2004) taxonomy of ICT affordances. The affordances include; "Accessibility, Speed of change, Diversity, Communication and Collaboration, Reflection, Multimodal, Risk, fragility and uncertainty, Immediacy, Monopolisation and Surveillance" (Conole and Dyke, 2004, p.114). With all these affordances, the Physical Science teacher should be able to generate an informed decision on how to structure a meaningful lesson.

Affordances of Tablets

While evidence in the literature is still limited, specific affordances available in Tablets such as immediacy make these ICT tools more suited for supporting interactive activities that facilitate group work (Wong et al., 2013). Tablets may enable a greater degree of learning through repetition in a Physical Science class for instance, in learning tasks related to laboratory-based experiments. In terms of portability, Tablets are more portable than Smartboards. Furthermore, working with Tablets ensures that feedback is received instantly. Tablets are also multifunctional in terms of interactivity due to their ability to handle a variety of applications.

Affordances of Smartboards

Smartboards come in different sizes, which makes them appropriate for use in both small and large classes. Moss et al. (2007) confirm the multi-modal affordances of whiteboards supported by a wide range of different learning styles. For example, a multimodal learning design consists of the interconnection of the modes such as written text, music, sound, and visual communication in teaching a single concept. Finally, this research will focus more on Conole

and Dyke (2004) `s affordances that spearhead the systematic application of the use of ICT in teaching and learning with a view to Physical Science.

1.11 Research Methodology

There are three common research methods; quantitative, qualitative, and triangulation (McMillan and Schumacher, 2014; Robson, 2013; Zikmund and Babin, 2010). Qualitative research is primarily exploratory research. Madzudzo (2020) emphasizes that to realise the benefits of qualitative research methods, understanding and listening to individuals, societies, and organisations affected by the phenomena is required. According to Miles et al. (2014) qualitative research is a craft that assists in developing concepts, insights, and understandings from patterns in the data rather than collecting data to assess preconceived theories. Quantitative research is used to quantify the problem by way of generating numerical data or data that can be transformed into usable statistics (Brannen 2017). Quantitative techniques conclude by proving or disproving a specific theory that was tested (Madzudzo, 2020). Triangulation combines the use of qualitative, and quantitative methods in one research design. For this research, a qualitative approach that employs case study research was used. Empirical data was collected from teachers and document analysis conducted to determine what is of value in the teaching and learning of Physical Science with ICTs.

1.11.2 Population and sample

A proper description of the research population makes it easier for the researcher to know who is or is not eligible for consideration in the final sample for data collection (Leedy & Omrod, 2018). In this study, the population included teachers from schools that have implemented ICT in teaching and learning, ad offer Physical Science as a subject. To reduce the population into a small manageable group, the researchers used the convenience sampling method. This method was used because the researcher sought to recruit participants currently using Smartboards and Tablets in the teaching of Physical Science in their schools.

1.11.3 Primary data collection process

- The in-depth interviews

The motivation for using the case study research approach lies in the fact that it helps to investigate a phenomenon within its real-life context, based on an in-depth investigation of a single individual, group, or event (Cooper and Schindler (2012). Likewise, this research sought to explore the pedagogical value of the use of Smartboards and Tablets in the Physical Science class. In principle, it was an in-depth investigation of the Physical Science classrooms of two selected schools. Data collection in this case study incorporated interviews with two Physical Science teachers froom the two schools to understand their experiences on using technology in lesson delivery of this subject.

- Observations

Leedy and Ormrod (2018) describe classroom observation as a qualitative approach used to typify the quality of teaching and learning through the use of an observation protocol. The benefit of using an observation approach is that the researcher might obtain detailed insights about the group of participants and its behaviours that could not be obtained in any other way (Creswell, 2014; Leedy, &Ormrod, 2016). The current study sought to explore the extent to which Tablets and Smartboard Technology can be trusted as an integral teaching and learning aid in grade 12 Physical Science classrooms. As a result, the researcher made use of observations as a method of data collection to gain a situational experience of how these technologies are used in practice to enhance teaching and learning. The researcher had to sit as a passive learner in both lessons conducted by the two teachers observing and video recording.

1.12 Data Analysis

According to Beck (2003:96), one of the purposes of data analysis is to interpret and convert the data into the description of the phenomenon. The data were grouped into categories (themes) in terms of the relationships that the data provided. Responses were used to test the viability of Smartboard technology and Tablet computers, through a detailed analysis of themes derived from the qualitative data. An analytical tool developed by Ndlovu (2015, p.106) was modified and used to present and analyse data. The analytical tool presents three different columns, the first is media forms associated with each ICT tool. Each media form results in certain affordances recorded in the second column. The evidence columns are also added to indicate if Smartboards and Tablets were used or referred to be used with the respective media form during the observed lesson. Also, the use setting column helps to determine whether these

ICT tools were used in the observed class or used after class. Finally, the last column helps to determine if these affordances lead to enhancing teaching and learning of Physical Science.

1.13 Ethical Considerations

Research ethics is specifically interested in the analysis of ethical issues that are raised when people are involved as participants in research, and Miller et al. (2012) state that ethical concerns are likely to occur at all stages of a research study. Saunders et al. (2018) highlight three main ethical issues that the researcher must consider, these are:

1. Protection of human participants
2. The research must serve the interests of individuals, groups, and/or society.
3. The management of risk, protection of confidentiality, well-grounded data collection processes, data storage, and the process of informed consent.

To ensure that the study is not in violation of research ethics, the university granted the researcher permission to collect data using the university's name. As a result, the researcher applied for an ethical clearance which allowed the field worker to get access to respondents. The ethical clearance was obtained from the University of the Witwatersrand Research Ethics Committee. Also, the target respondents fall within the jurisdiction of the Gauteng Department of Education. Consequently, the researcher applied for permission to access the schools from both the School Principal and from the Gauteng Department of Education. In essence, the ethical decisions were considered before interacting with the respondents. The researcher implemented measures to ensure that all respondents' privacy was maintained. The measures ensured that the study's participants were protected from harm (physical and emotional). The data collection process was conducted in the participants' respective learning environments. The researcher assured respondents that the research was solely for academic purposes, and the respondents could get access to the data and the study's results on request.

1.14 Limitations of the Study

This study focused only on two schools due to budgetary, time, and resource constraints. For this reason, any generalisations in this research to other provinces and sector departments in South Africa and other countries should be undertaken with caution.

1.15 Organisation of the Research

This research is outlined in seven chapters. Chapter one (1) provides an introduction and background information on the research topic, outlining the key frameworks and the framework of the methodology. Chapter two (2), reviews previous researches, books, and papers to build a framework for this research. Chapter three (3) details the research design or strategy followed to achieve the objectives of this research. Chapter four (4), details the development of the analytical framework used to analyse the results. Chapter five (5), provides a detailed analysis and representation of the findings. Chapter six (6) presents the value of the teacher`s integration of Tablets and Smartboards into teaching. This final chapter provides recommendations and summarises the study.

Chapter Two

LITERATURE REVIEW

2.1 Introduction

The preceding chapter (Chapter 1), proposed the direction of this research, and it also provided the introductory background to the study, stating the research questions and objectives as supported by the problem statement. To justify the reason to continue with this research, the previous chapter also highlighted the significance of the research. Furthermore, it gratified the preliminary review of literature on smart technologies as well as models and theories that help to identify the pedagogical value and the implementation of these smart technologies. The current chapter provides a more detailed review of the literature on the pedagogical value of Smartboards and Tablets. The chapter starts by giving a background context to ICT in education and goes on to define the policies that support the implementation of Smart technologies. Another major aim of this chapter is to provide evidence of the global, regional, national, and local trends on the pedagogical value of Smartboards and Tablets for teaching and learning in the context of teaching Physical Science. Given all that has been mentioned, a detailed review is done on the teacher perception regarding implementation and use of the Smartboards and Tablets in the teaching and learning of Physical Science. A review of the model used to guide the enquiry on the teacher's approach in incorporating the said gadgets in the classroom.

2.2 Background Context of ICT in Education

The rapid transformation of the global economy evident from the characteristics and the demands of the 4th industrial revolution suggests the significance of technology in economic activities(Kempner & Spring, 2000; Bybee, 2010). The economic function thirsts for technological infusion just as much as the economy (Anwer S. Al-Zahrani, 2007; Jubien, 2013; Siiman et al., 2017). The results of the study conducted by Johnson and Lybecker (2009) suggest that the introduction of technology in the economic environment is mainly due to how easy the process of accessing and transferring information is, which is also evident in the education function. Based on this assessment, Grimus and Ebner (2015), stress that it is logical

to admit that in the present time, teachers and learners require prospects that simplify the process of teaching and learning. In support of the above-stated argument, it is imperative to recognise that the foundation of the technology-economy is education (Leidner & Jarvenpaa, 1995; Higgins, Xiao, & Katsipataki, 2012; Reychav, Dunaway, & Kobayashi, 2015). Therefore, the effectiveness of technology should be experienced at schools before it is received in the industry. ICT in schools is also introduced to substitute and enhance old practices and align all approaches to lesson deliveries to the available technologies. The introduction of technologies in the classrooms was not an easy penetration as stakeholders such as teachers and learners varied in their perceptions on how they should handle these technologies. The issue of preparedness was a cause for concern although training programs were put in place.

ICT has emerged as a supplement to the traditional methods of teaching and learning. The introduction of Smartboards and Tablets in South African schools was not just for schools to have the gadgets, rather there was a perceived idea that the pass rate will go up. Yapici and Karakoyun (2016) support this view by asserting that Smartboards can help learners to develop self-confidence and can help to understand subject content.

In a study by Enriquez (2010), Tablets were perceived to have many advantages such as helping to improve performance, increase attentiveness, as well as improving the ability to organise class material. Jensen (2018) further emphasise the value of Smartboards in teaching and learning as important tools to reduce learning time, motivate students through visual elements, affording individual assessments, and self and peer feedback. Physical Science, because of its complex nature would benefit immensely if such technologies are infused in the lessons. Teachers could cover and manage content within stipulated times thereby dedicating more time for revision. Despite all this glittering appraisal, Lai (2010) sensationally claims that the use of Smartboards and Tablets is a source of teacher stress as some students tend to get distracted and use the technologies on non-course-related activities. Voogt (2012) argued that the introduction of ICTs in schools was hinged on three reasons namely: economic, social, and pedagogic. This literally means, on the economic aspect the end product should be able to adapt to the world of work while they can socially participate and enhance teaching and learning.

2.3 Government Policy on ICT

The South African government has taken a strong position in introducing ICTs in schools noting the great stride and impact in the transformation of the education systems across the world. ICT is pillar number 6 in the strategic policy employed by the Department of Education in Gauteng. In order to have a successful implementation of the policy, the government availed ICT resources in most schools in Gauteng. Smartboards and Tablets were installed in most township schools which shows its strong desire for technological application in the delivery of content in teaching and learning in the education system. This was envisaged by the Department of Education (2014) as an idea of introducing ICTs as a way of improving standards and quality of education.

2.3.1 Physical Science CAPS document

The CAPS document is not explicit in its approach towards the integration of technology in the teaching and learning of Physical Science. The general aims of the curriculum as indicated in the CAPS document (2011) emphasises the acquisition of knowledge and skills that will add value to the learner's lives. Furthermore, it highlights the importance of linking learnt content to the global context. It further states that it aims to 'facilitate the transition of learners from educational institutions to the workplace' (2011, p5). The use of technology is silently mentioned. This is in consideration with the world that has become more digital. It is in this endeavor that the CAPS document tries to make it clear that every learner who passes matric should have some knowledge of the use of technology as they move to tertiary education. This is envisaged in its general aims in the CAPS document (2011, p5) where it says, 'learners will use science and technology effectively and productively'. However, nothing is specific in regards to giving guidelines on how the technology can be incorporated in the Physical Science CAPS document.

The silence about the integration of technology brings the view that the CAPS document should be revisited to ensure that it highlights the need for the integration of ICTs in the teaching and learning of Physical Science. For example, software such as Physics Education Technology (PhET) interactive simulations can be relevant for learners to understand the behaviour of atoms. Otherwise, if it is not enforced in the policy documents, teachers will not integrate ICTs in their lesson deliveries.

2.3.2 White Paper on e-Education

The Department of Education is guided by the White Paper on e-Education on the integration of digital learning tools and resources in teaching and learning (Christie, 2008). ICTs have tools that create greater access to learning opportunities, redress inequalities, improve the quality of teaching and learning, and provide personalised learning experiences. The introduction of ICTs in schools has diversified the teaching and learning approach as teachers including learners can use various media forms to engage, gather, sort, and analyse information. Naledi Pandor (2004) the then minister of education reiterated and clarified the purpose of the white paper on education. She said it sets out the response by the government to the new information and communication technology environment in education. The white paper responds to the need of a teacher to familiarise themself with different tools to develop and enhance his/her teaching strategy. The paramount idea in this approach is to improve the quality of education and training. According to the white paper on e-Education (2004: p8), ICTs have a huge 'impact on the curriculum development and delivery and continue to pose new challenges for education and training systems around the world'. However, the introduction of technology in teaching and learning in the South African context helped in the transformation of the education system post-apartheid, to enhance diverse skills and knowledge, and to increase the credibility, quality, and efficiency of education in South Africa (CDE, 2011).

2.4. Global Trends on the use of Smartboards and Tablets for Teaching and Learning

There is a spike in the use of digital technologies worldwide which has widened or increased the growth of the information society. Many countries have taken the initiative to incorporate technologies in their secondary school subjects' syllabi. This will have a bearing on the widening of market space for itself. The general belief across countries is that, people all over the world are becoming interconnected in all levels of life through various networking platforms. This is in line with the definition by (Usman, Hassan & Qadri, 2014) who points out that globalisation is a transformation influencing social interactions and exchange relations and transactions, yielding trans-border, transcontinental or interregional mobility and networks of activity, interaction, and power. Most countries are making efforts to come up with the best innovations and practices to infuse technologies in the educational space. This upsurge in the use of technologies introduced in the education systems in the world is an initiative to make

education match with the developing trends of the digital world. Even with extremely constrained financial resources, some countries are purchasing one laptop for every primary or secondary student (Kozma and Vota 2014).

The introduction of Smartboards and Tablets in the education systems by some countries is meant to be a pedagogical intervention to assist the teacher in the transfer of knowledge to a learner. The emergence of new instructional technologies in K-12 classrooms in the United States of America (iPad, iPod, and Smartboards) offers the potential to help students become digital learners that allow them to be self-directed, and independent learners (Project Tomorrow, 2012). The assumption is that the way they conceive information will greatly change the way they acquire knowledge. Learning & the Brain Conference, (2011) found out that the use of Tablets in the classroom has shaped the way students at all levels in K-12 schools (USA) learn, think, read, socialize, and interpret information in the teaching-learning process. Research conducted by Davidovitch and Yavich (2016) in Israel confirmed that the use of Smartboards as a mechanism of change in the school system significantly impacted the cognitive levels of learners. Zhang et al (2016) found that the Chinese government is actively adapting itself to the need of international competition in the circumstances of globalization, and also fully understands that informationisation is the general trend of the development of the present world as well as the important power that promotes economic and social reform. Despite all these encouraging ideas China is faced with daunting tasks to implement fully ICT in education. Zhang et al (2016) picked up four critical challenges in their endeavor to introduce technology to the education system. These are: lack of investment in education in general, extremely unbalanced development of education, unreasonable personnel structure and mode for talent training, and incomprehensive ideas of educational institutional reform. If China being a developed country is faced with such challenges, then it's safe to assume that under-developed countries' problems might be greater. The introduction of ICTs in under-developed countries appears to be a big dream.

It is evident that the direction the world is taking both in the field of work and tertiary education, there is more use of technology in every aspect. More countries are eager to introduce the use of technology in teaching and learning. Although this is noble, there are challenges associated with implementation. The issue of finance is a huge factor in trying to roll out the program. The problems are also compounded by an unwillingness by some teachers refusing to change or adapt to the new challenges. However, more and more countries are prioritising the introduction of technology in teaching and learning. Potentially, this could be of great benefit to such subjects as Physical Science that require more illustrations and experiments.

2.5. Teaching of Physical Science in South Africa

Physical Science is a complex subject that requires great expertise and skill from a teacher to deliver a meaningful lesson that will add value to the scientific bank of knowledge of a learner. Physical Science is divided into two distinct components, which are Physics and Chemistry. Because of its nature which requires experiments, illustrations and clear explanations of key chemical and physical jargon, it requires effective methods of planning and teaching. A study by Saragaram (2019) focused on the benefits and challenges of teaching Physical Science in South Africa found that collaboration through Lesson Study enhanced teachers' professional teaching strategies, networking skills, lesson plan writing, classroom management, self-efficacy, and positive attitudes towards teaching. There is a lot involved in trying to design a meaningful compact lesson that adds value to the learners. Efforts to revamp the South African education system through improving teacher's competence, professional knowledge, behaviour, self-efficacy, classroom practice, skills, and professional status as teachers have been ongoing for several years (Hofmeyr, 2015). South Africa has a lot of programs to help teachers in the use of ICTs to improve their teaching strategies for the development of a learner, such as teacher development programs facilitated by the Department of Education.

Since Physical Science is divided into two specific parts, Physics and Chemistry, the teacher's approach in drafting lessons is guided by this, together with what the syllabus and the CAPS document prescribe. Here is how the Physics lesson is structured which has a more similar approach to Chemistry: the lesson breakdown should be guided by the school timetabling system. However, they need to adhere to the prescribed time allocation of Physical Science per week in the CAPS Document, which is four hours in this case (CAPS Document 2011). It is the prerogative of the schools to decide how this time is broken down per week. The teacher has the task to manage time in each lesson delivery according to the structure of the lesson. The teacher has to work on two or three examples before activities and homework are given to the learners. Operating under these conditions impacts heavily on the teacher as it is time-consuming and resource-intensive. Homework should be written on the chalkboard for learners to copy. In some cases, when copies are required due to the nature of the homework exercise, the challenge of a faulty or non-working photo-copying machine exists.

2.6 Teachers' Perceptions Regarding the Implementation of ICTs

For a successful implementation of technology in a classroom environment, the first port of call is the teacher. It is paramount to look at how the teacher's perceptions influence his/her beliefs and attitudes in the introduction of these technologies in their lesson deliveries. Ambusaidi and Al-Farei, (2017) and; Gun, (2012) describes attitude as the way an individual's personality, beliefs, values, behaviours, and motivations attained from experience are expressed through words and behaviour. Teaching and learning on a digital platform is meant to improve the effectiveness of teachers, enhance knowledge transfer, simplify interaction with course content, and develop the talent of learners (Schott & Seel, 2015: Margaryan et al, 2015). Governments and stakeholders may come up with policies as guidelines to be followed by teachers when introducing ICTs in the classrooms, but it is the teacher's attitude that informs successful implementation. Mlotshwa (2018) found out that most of the research on teacher's perceptions of ICTs focused on the extrinsic behaviour of the teacher while ignoring the intrinsic behaviour. Mlotshwa (2018) argues that there must be a holistic search on the perception of teachers on the introduction of ICTs in schools. Mlotshwa (2018) further states studies seldom focus on intrinsic motivations and perceptions that are related to beliefs, discourse, and philosophies held by teachers.

The teacher's attitude reflects their perceived use of ICTs in their lesson delivery. Instructional tools such as Smartboards and computers must give teachers an impetus to access curriculum material. However, this has been culminated by the desire to use them by the teachers. Researches have shown that teachers' perception of the use of technology has increased. Besides being called the world's biggest library because of its vast source of information, the United States Department of Education (2003) found out that teachers and parents considered technology as an integral part of providing high-quality education. This reflects the need for ICTs in the educational cycle era where some systems have been disrupted by pandemics. The thirst to acquire technological skills by teachers has leaped in the educational fraternity with calls to make this a priority. Teachers have developed the avidity in learning basic computer skills to stand up to the current challenge, the disruption caused by COVID-19. Ertmer (1999) believes that teachers have to change their mind-set in order to achieve fundamental, changes in classroom teaching practices with the inclusion of technology.

2.7 The Conversational Framework

To get a clear understanding of the pedagogical value imposed by these gadgets a framework adopted and modified from Laurillard (2012) was used in this study. The Conversational Framework, according to her brings out the issue of dialogue between the teacher and the learner. Laurillard (2012) subtly highlights that the approach to teaching and learning cannot be handled lightly, there should be a holistic approach synchronising all aspects. This means that every tool that can help in teaching and learning must be taken seriously. The Conversational Framework invigorates the direction and approach that will unravel techniques in teaching and learning with the incorporation of technology. Laurillard (2012; p. 82) states "what it takes to teach cannot be determined directly from what it takes to learn, which means that teachers must be willing to treat the process as essentially problematic, iterative, and always improvable; we must stop assuming that teaching can be theorized like a natural science, and treat it like a design science".

The Conversational Framework captures and describes significant features expressed in integrating technology in teaching and learning. It is ideal for High School Physical Science teaching as it encompasses the following five key events, acquisition, discovery, dialogue, practice and creation. Laurillard's approach insinuates a structured pathway in developing pedagogical patterns which incorporate smooth integration of technology in a particular subject. The teaching of Physical Science using Smartboards and Tablets is not spontaneous, rather the skill is with the teacher on how to select tools and resources that will inspire and create a learning environment.

Figure 2.1 below, the Conversational Framework adopted from Laurillard (2012) offers a more progressive explanation of how technology can be incorporated in teaching and learning.

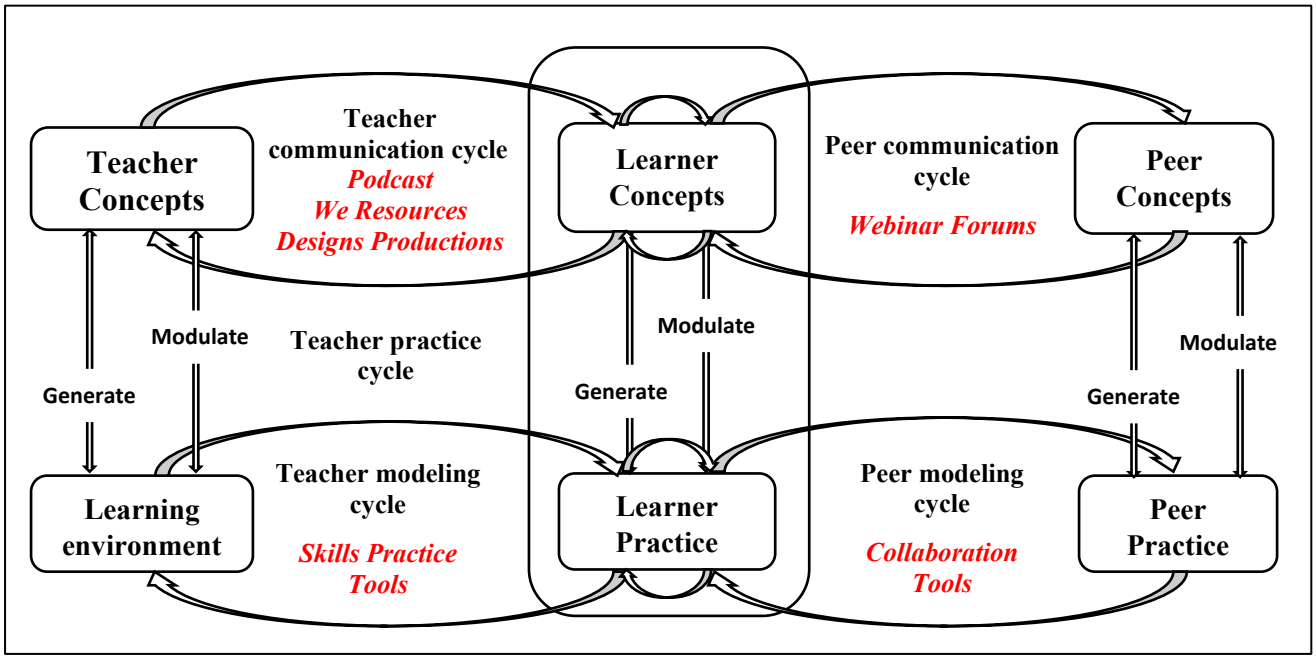

Figure 2.1: Progressive explanation of technology use

As portrayed by the figure above, this Framework can be used on a variety of learning technologies. The Framework illustrates the interaction between the teacher and the learners who would venture into areas that cannot be portrayed by the physical presence of the teacher. Physical Science being such a complex subject that requires experiments, teachers found ways to use various technological tools in assisting and covering difficult areas. For instance, a teacher clarifies a scientific concept orally and an individual learner or fellow learners asks a question or create new articulation based on their understanding of the concepts. This created an intrinsic motivation by the teachers in wanting to make use of these gadgets in their teaching and learning experience. In fact, because of the limited number of days of attendance during the COVID19 pandemic, teachers from the two schools made exceptional use of technology to convey very vital information through this availed technology. It is therefore important to look at the following cycles of the conversational framework;

- **The teacher practice cycle (TPC)**

In the Teacher Practice Cycle (TPC), learners can generate their articulations and actions, of which these conceptions and actions modulate their concepts and practice. As a result, the conversational framework use "the adaptation of task goals in light of students' descriptions and adaptation of action in light of goals and feedback" Laurillard 2012, p. 86). On the other end, teachers modulate learner`s actions in light of their actions and feedback. In that case, the conversational framework enables teachers to use their "reflection on the learner`s actions to

modify descriptions and the reflection on concepts in light of learner`s experience" Laurillard 2012, p. 86).

- **The teacher communication cycle (TCC)**

According to Holmberg (2016), most teachers frequently use technology to enhance their communication with learners, through discussions, portals and emails as well as to share class content. For instance, using texts and videos detailing content to be covered in class, gives learners the opportunity to get information differently.

- **The teacher modelling cycle (TMC)**

The teacher modelling cycle characteristically encompasses the construction of exercises that generate learner understanding of concepts, which are indicative of their current present conceptualisation of subject content. Given that learners have access to Tablets, with applications such as word processing software, they can model their work using the inbuilt features of spelling and grammar checks (Holmberg, 2016). Thus improving their skills.

- **The peer communication cycle (PCC)**

The primary intention of introducing learners into groups is to encourage constructive criticism, exposing learners to group dynamics, which is important for creating and sharing subject content. The conversation framework supports this view, in the sense that technology assist learners in connecting through the internet and share information. Learners can download relevant content and use it as a proxy for discussions.

- **The peer modelling cycle (PMC)**

In the PMC, the main aim is to enhance collaboration, as learners are inspired to share exemplifications of their practices. In principle, PMC afford learners the aptitude to model their practices and those of their peers.

To understand the affordances associated with the Smartboards and Tablets, the Conversational Framework is used to analyse and identify different media forms.

2.7.1 Media forms

The Conversational Framework is an integral part of the Conceptual Framework developed for this research and it is the basis for understanding the role of media in teaching and learning using technologies such as Tablets and Smartboards. Owing to the structure and composition

of the Conversational Framework, this research integrates the Conversational Framework to analyse educational experiences associated with Smartboards and Tablets. In essence, the Smartboards and Tablets bring in different learning experiences that could enhance learning in the case of Physical Science where videos and images can be used to explain key concepts. The Conversational Framework suggests five different learning experiences, which are termed, Laurillard's taxonomy of educational media technologies, identified as "narrative, interactive, communicative, adaptive and productive respectively" (Laurillard, 2002, p .107).

These five experiences are unnoticeable unless they are supported by different kinds of media, which the Framework suggests as elements that support the smooth exchange of information between the "transmitting sources and the receiver of the message" (Romiszowski, 1988; Laurillard, 2002). Also, the framework captures and describes the significance of media forms in integrating technology in any learning phase of any activity. To capture the different unique roles of media forms, the Conversational Framework suggests groupings of media, which Laurillard's (2002) elaborates as media forms' grouping, based on clarifying the specific role of the kind of affordances that media brings in at the moment they are integrated into any learning phase in the activity. In principle, media forms include; productive, communicative, narrative, interactive, and adaptive media (Laurillard, 2002).

Productive Media Forms

Tools that learners use to produce or express themselves as a way of demonstrating their understanding of the learnt skills and knowledge are referred to as productive media forms (Laurillard, 2002). These indicate levels of articulation, interactivity, user control, and engagement as learners articulate their conceptions. On this note, it is evident that productive media forms are associated with articulation affordance. Examples of evidence of knowledge acquisition and articulation can be a typed piece of work using a word processor on a Tablet or using smart notebook software on interactive whiteboards (Hall & Higgins, 2005). Ultimately, the pedagogical value addition associated with productive media forms is knowledge construction (Ndlovu, 2015). This research uses these conceptions to structure the Conceptual Framework to expound on the media forms and affordances of Tablets and Smartboard.

Narrative Media Forms

Although narrative media forms are linear, highly structured, and non-interactive, the Conversational Framework suggests that the media should be structured such that it engages the learners and encourage experiential learning (Laurillard, 2002). Engaging narrative media are characterised with properties that subconsciously immerse learners into experiential

learning. According to Ndlovu (2015), media such as lecture, print, audio vision, television, video, and DVD are close examples of narrative media. Narrative media forms as presented in the Conversational Framework are also evident in the use of Smartboards and tablets. In essence, the Smartboards expressively facilitate engagement with narrative media, which are non-interactive (Laurillard, 2002).

Interactive Media Forms

To trace the importance of learner involvement at any phase of the learning activity when using Smartboards and Tablets, this research includes interactive media forms explained in the Conversational Framework. Aside from the fact that interactive media allows learners to reconnoitre in a non-linear way, the content only allows them to manipulate it but remains unaltered (Treem & Leonardi, 2012). However, the Conversational Framework presents interactive media as means of communication in which the output on the electronic device being used for learning depends on the inputs by the learner (Wang et al., 2010; Petko, 2012). Laurillard's (2002:107) description of interactive media emphasised the significance of promoting the pace at which students learn, that is through the feedback of the content taught. Furthermore, interactive multimedia permits the learner to control, combine, and manipulate diverse media types (text, animation, audio, computer graphics, and video materials (Petko, 2012; Venkatesh, Croteau & Rabah, 2014). According to Ndlovu (2015), narrative media forms have a pedagogical value associated with non-linear affordances, which lead to multimodality in learning.

Communicative Media Forms

Although Smartboards do not necessitate the exchange of information between teachers and learners and amongst learners, Tablets can assist with communicative media. Hence this research adopted the communicative media form in designing the Conceptual Framework to ascertain how these media forms assist learning with Tablets. Treem and Leonardi (2012) posit that communicative media supports conversations that are critical for descriptions, debate, reflection, feedback, and goals. However, the benefits of this media form to learning depend mainly on the quality of the interaction as constructed and guided by the teacher or the mediator. Furthermore, communicative media forms are associated with collaboration affordances, which is evident in discussions while re-describing concepts.

Adaptive Media Forms

Based on the concepts presented in the Conversational Framework, adaptive media forms adjust responses to the actions of the learner. In essence, (Laurillard, 2002:126) suggests that adaptive media enables learners to learn from using "the modelling capability of computer". More so, the Conversational Framework suggests that the significance of adaptive media is reinforced by high values of interactivity, exploration possibilities, and achievement awareness (Venkatesh, Croteau & Rabah, 2014). On the same note, Petko (2012) is of the opinion that adaptive media have higher values of user control and competition as the learner engages with the taught content.

2.8 Conclusion

In essence, this chapter gives the reader the literature backing the theoretical background to the main question and objectives. It touched on scripted evidence that could support the use of technology in teaching and learning and whether there is any pedagogical value in their use. The following chapter will give a detailed overview of the research methodology that has been used. It includes the research design, the data collection, and procedures.

Chapter Three

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research approach that has been employed in this study. A qualitative research method that employs observation and structured interviews were used. The in-depth interviews and classroom observations were used to expose key elements of the pedagogical value of the Smartboards and Tablets. This chapter also outlines the research design deployed in the data collection procedure which also includes the instruments used.

3.2 Research Methods

A qualitative research study according to Johnstone (2000) is concerned with how individuals and groups view, understand the world and construct meaning out of their experiences. Qualitative research includes a wide range of philosophies, research purposes, intended audiences, methods, and reporting styles (Denzin & Lincoln, 1994; Greene, 1994); Drisko, 1997). The qualitative research approach demands that the world be examined with the assumption that nothing is trivial, that everything has the potential of being a clue that might unlock a more comprehensive understanding of what is being studied (Bogdan and Biklen 1998, p.6). The qualitative research method was adopted because this research dealt with the teachers' perceptions, attitudes, and approaches in using Smartboards and Tablets in their lesson delivery in teaching Physical Science at Further Education and Training (FET).

3.3 Research Sites and Respondents

3.3.1 Research sites

Two schools offering the subject Physical Science were selected in Gauteng as they have Smartboards installed since 2015 and Tablets given to learners in the same year. The choice of the schools was driven by the easy accessibility and the resources that helped answer my

research questions. These are township schools that were also previously disadvantaged by the system that classified other schools as superior to others.

3.4 Sampling

Seaberg (1998) defines sampling as a small proportion of the total set of objects, individuals, or events which together make up the subject of our study. A purposive sampling method was used in selecting the Physical Science teachers from two secondary schools who use Smartboards and Tablets in teaching the subject. The teachers were interviewed and a lesson observation was done for only one session per school. Due to COVID-19 restrictions, the classes had been reduced to a maximum of 20 students. The initial targeted number per class was 35.

3.4.2 Respondents

The research was focused on FET teachers who teach grades 10-12. The target group was grade 10 or 11 but due to the disruptions precipitated by COVID-19 grade 12 students became the focus group. During the collection of data, the grade 12 class was the only grade allowed to return to school.

3.5 Data Collection

The instruments used to collect data in this study were an in-depth structured interview with the teachers and one classroom lesson observation per teacher. The use of observation was to get insights into how the teacher and the learners manipulate their gadgets to achieve an understanding of intended learning outcomes.

3.5.1 Teacher interview

An interview is defined by Bogdan and Biklen (1992) as a purposeful conversation, usually between two people. Sometimes it involves more people and can be directed by one of them to get information from the other. Mason (1996: p40) believes that an interview will give “access

to those interpretations and understanding which are revealed in some way". The teacher interview was done to get a glimpse of the background of the teacher before the school started using the technologies up until they were introduced. This was done to understand their teaching philosophy and their experiences in the teaching of Physical Sciences with or without technologies. During the interview, COVID-19 guidelines were followed, the guidelines comprise wearing a mask, applying hand sanitiser, and adhering to social distancing rules.

3.5.2 Observation

Bell (2005; p184) believes that observations can be "useful in discovering whether people do what they say they do, or behave in the way they claim to behave". Observations try to justify preconceived ideas and reveal signs of bias. To understand the everyday actions of the teacher and her/his students, observations were used in this environment. This helped to get first-hand information on how the teachers manipulate their lessons together with the technologies in delivering Physical Science classes. The researcher observed the lessons of the two Physical Science teachers to understand how they use Smartboards and Tablets for teaching and learning. However, according to Bell (2005) observation schedules can take any form as long as it suits one's purpose. In this instance, I had to sit in a class and be a passive learner and capture evidence by way of video filming and taking pictures. This allowed the researcher to observe learners interacting with their tablets. During this time, I remained focused on the research's objectives. The whole exercise was made simple because of the class sizes which were reduced to a maximum of twenty learners per class as one of the COVID 19 guidelines and regulations set out for the reopening of schools.

3.6 Data Analysis Procedure

Data analysis is defined by Gardner (2009: p 260) as "the process of inspecting, cleaning, transforming and modelling data to highlight useful information, suggesting conclusions and supporting decision-making". Teachers' experiences were captured through in-depth structured interviews to bring out the journey travelled from the point they started using technologies in their teaching experiences. One lesson observation was conducted on each teacher to gather data that will have a bearing on the main research question.

3.7 Analysis of Results

This section focuses on the findings of the research questions and objectives. Two Physical Science grade 12 classes were selected from two Gauteng Ekurhuleni North district schools. According to Burgess (1984, p.102) qualitative interviewing is 'conversation with a purpose'. Therefore, the dialogue with teachers sought to capture, perceptions and experiences of physical science teachers from these selected schools, who use Smartboards and Tablets to facilitate teaching and learning. The interviews with the teachers helped to retrieve the chronology of events on how they started using technology throughout their teaching experience. The interview narratives and the class observations were converted into text to allow for a thematic process of coding to identify relationships, differences, and similarities.

3.8 Validity and Reliability

Reliability is defined by Phelan and Wren (2005-06) as the degree to which an assessment tool produces stable and consistent results. However, they mention different types of reliability which can be employed depending on the focus of attention. Validity refers to the appropriateness, meaningfulness, correctness, and usefulness of the inferences that a researcher makes (Fraenkel & Wallen 2006). The class observation and interviews were regarded as valid as they provided accurate information on the results sought.

3.9 Limitations of the Study

Two schools were selected from only one district of Johannesburg and the findings cannot be generalised to all schools that have Smartboards and Tablets in South Africa. The study only focused on grade 12 groups and teachers of Physical Science. However, the results cannot have a direct link to the other grades and subjects in all schools. The collection of data from these two schools was riddled with challenges associated with changing programs initiated by the department trying to curb the spread of the coronavirus. Also, the targeted teachers who happened to be in the Senior Management Teams (SMT) were not readily available each time appointments were scheduled. Furthermore, due to COVID-19 regulations and guidelines, the

classes were reduced to a maximum of twenty learners instead of the anticipated full class of 35.

3.10 Ethical Issues

Requirements to conduct this research were fulfilled according to the University's Human Research Ethics Committee (Humanities). Since the research was carried out in public schools, consent was sought from the Department of Education. Both the research sites remained anonymous throughout. The privacy and confidentiality of all the respondents were protected for the entire duration of the study. Informed consent is achieved by providing subjects with an explanation of the research (McMillan & Schumacher 2006:143). Principals of the two schools were issued with request letters before going in to collect data. In addition, letters of consent were given to teachers, parents, and learners. The identity of all participants was kept anonymous throughout the research. The COVID-19 regulations and protocols which involve social distancing, wearing of masks, and hand sanitising were strictly adhered to at all times during class observations in both schools.

3.11 Conclusion

This chapter gave an overview of the choice of the research methods used. It also discussed the data collecting instruments and analysis employed in this research which helped focus on the research question. The following chapter presents the analysis and interpretation of the data.

Chapter Four

THE DEVELOPMENT OF THE ANALYTICAL FRAMEWORK

4.1 Introduction

The previous chapter presented the methodology for conducting this research, outlining the target population, data collection instruments, the proposed data analysis method, and tools. The preceding chapter also specified the delimitation of this research. Since this research aimed to ascertain the pedagogical value of Smartboards and Tablets in teaching and learning of Physical Science, the data collected must be converted into meaningful insights passed on the theoretical underpinning proposed by a working framework.

In order to analyse this data, this chapter looks into developing the analytical framework that is used to understand the relationship between the ICT tools (Smartboards and Tablets), associated media forms, affordances, evidence, use setting, and the resulting pedagogical value. Consequently, this chapter presents an analysis of the relationship between pedagogical integration of Smartboards and Tablets on teacher enacted and espoused practices and the associated pedagogical value evident from the affordances of Smartboards and Tablet computers, with the help of the following conceptual framework and analytical tool (figure 4.1) modified from Ndlovu (2015).

4.2 Developing a Data Analysis Tool

In this section, it is imperative to present the distinction between tools, media and affordances in order to understand how Smartboards and Tablets can add value to teaching and learning of Physical Science. According to Salomon's (1992, P.892), media can be understood as symbol systems, technologies as vehicles or tools for sharing media while affordances are externalities of media that can lead to pedagogical value. Therefore, to answer the question (why it is important to analyse the application of different media forms in classrooms (enacted practice)? This research used the relationship between media forms, affordances and their associated pedagogical value. Also, it is crucial to understand that the benefits of media in a classroom setup depend on how, they are used, why using them and when are they used for creating and sharing knowledge.

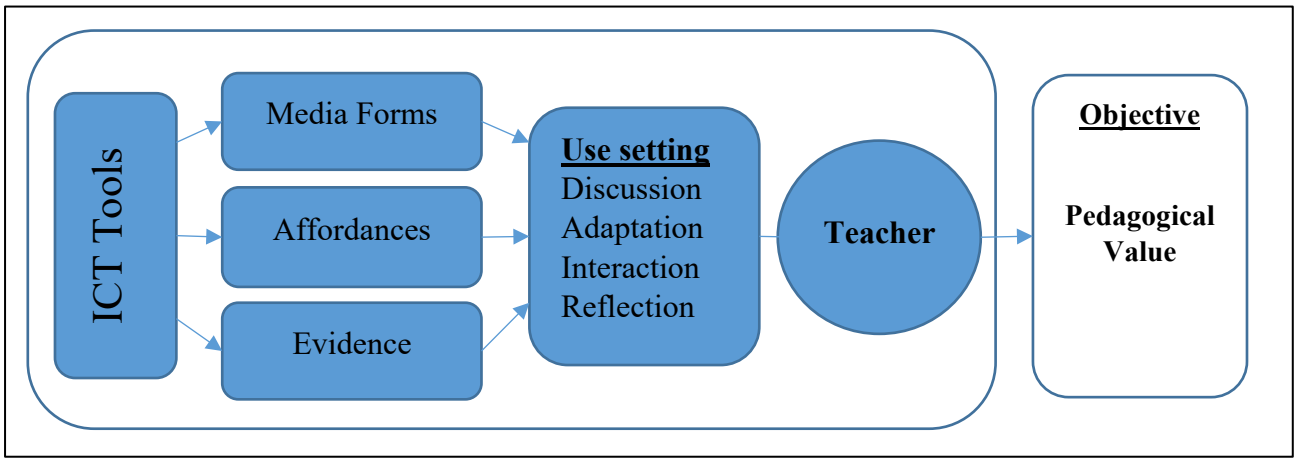

Figure 4.1: Conceptual Framework (Modified from Ndlovu 2015)

The following analytical tool was used to track whether there was going to be pedagogical value in a case where these two gadgets were used in the Physical Science classroom. This analytical tool is constructed from categories of five media forms developed by Laurillard (2002), which sought to compare key learning activities and these media forms, with the purpose of weighing the pedagogical value they bring into the learning process. In principle, these media forms were used to identify what value the Smartboards and Tablets add to the pedagogics of teaching and learning, in supplementing existing teaching and learning tools. In the classroom context, the teachers are the main users of these ICT tools mostly the Smartboards. Learners use mostly the Tablets during guided class discussions and practice, where the teacher give learners the aptitude to develop their concept understanding. This analytic tool selects only media forms from Laurillard's (2002) with the affordances explained by Conole and Dyke (2004), which are applicable to Smartboards and Tablets.

4.3 Development of the Analysis Tool

The application of Smartboards and Tablets in a Physical Science class depends on the relationship between learning objectives, teaching methods, and learning tools. As a result, the following subsections describe different affordances of Smartboards and Tablets and how they fit into the analytical tool,

4.3.1 Productive media form

Productive media is an activity, behaviour and progression form that involves higher levels of engagement between the learner and the ICT tools in order to understand and learn concepts. In essence, these are the tools that learners use to produce or express themselves as a way of demonstrating their understanding of the learnt skills and knowledge are referred to as productive media forms (Laurillard, 2002).

Table 4.1: Productive media form

Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Productive	Articulation	Animation / Model	Face to face and Remote	Knowledge construction

These indicates levels of articulation, interactivity, user control, and engagement as learners articulate their conceptions. On this note, it is evident that productive media forms are associated with the articulation affordances. Examples of evidence of knowledge acquisition and articulation can be a typed piece of work using word processor on Tablet or using smart notebook software on interactive whiteboards (Hall & Higgins, 2005). Ultimately, the pedagogical value addition associated with productive media forms is knowledge construction (Ndlovu, 2015). This research uses these conceptions to structure the Conceptual Framework to expound on the media forms and affordances of Tablets and Smartboards.

4.3.2 Narrative media forms

Although narrative media forms are linear, highly structured, and non-interactive, the Conversational Framework suggest that the media should be structured such that it engages the learners and encourage experiential learning (Laurillard, 2002).

Table 4. 2: Narrative media forms

Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Narrative	Non-linear	Multimodality	Face to face	Apprehending structure

Engaging narrative media are characterised with properties that subconsciously immerse learner into experiential learning. According to Ndlovu (2015), media such as lecture, print, audio vision, television, video, and DVD are close examples of narrative media. Narrative

media forms as presented in the Conversational Framework are also evident in the use of Smartboards and tablets. In essence, the Smartboards expressively facilitate engagement with narrative media, which are non-interactive (Laurillard, 2002).

4.3.3 Interactive media forms

Laurillard (2002:107) description of interactive media emphasised the significance of prompting the pace at which students learn, that is through feedback of the content taught. In addition, interactive multimedia permits the learner to control, combine, and manipulate diverse of media types (text, animation, audio, computer graphics and video materials (Petko, 2012; Venkatesh, Croteau & Rabah, 2014). According to Ndlovu (2015), narrative media forms have pedagogical value associated with non-linear affordances, which lead to multimodality in learning.

Table 4.3: Interactive media forms

Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Interactive	Immediacy	Immediate feedback	Remote and face to face	Exploring: misconceptions and amend

In order to trace the importance of learner involvement at any phase of the learning activity when using Smartboards and Tablets, this research includes interactive media forms explained in the Conversational Framework. Aside from the fact that interactive media allows learners to reconnoitre in a non-linear way, the content only allows them to manipulate it but remain unaltered (Treem & Leonardi, 2012). However, the Conversational Framework presents interactive media as means of communication in which the output on the electronic device being used for learning depends on the inputs by the learner (Wang et al., 2010; Petko, 2012).

4.3.4 Communicative media forms

Communicative media is operational at the discursive phase in the Conversational Framework where technology can be used in a class or groups to discuss, debate or perform given tasks or challenges.

Table 4.4: Communicative media forms

Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Communicative	Collaboration	Discussion	Face to face class /group	Re-description of concepts

Although Smartboards do not necessitate exchange of information between teachers and learners and amongst learners, Tablets can assist with communicative media. Hence, this research adopted the communicative media form in designing the Conceptual Framework to ascertain how these media forms assist learning with Tablets. Treem and Leonardi (2012) posits that, communicative media supports conversations which is critical for descriptions, debate, reflection, feedback and goals. However, the benefits of this media form to learning, depends mainly on the quality of the interaction as constructed and guided by the teacher or the mediator. Furthermore, communicative media forms are associated with collaboration affordances, which is evident in discussions while re-describing concepts.

4.3.5 Adaptive media forms

Based on the conception presented in the Conversational framework, adaptive media forms adjust responses to the actions of the learner. In essence, (Laurillard, 2002:126) suggests that adaptive media enables learners to learn from using "the modelling capability of computer".

Table 4.5: Adaptive media forms

Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Adaptive	Diversity	Reproduction: Model/role play	Remote and Face to face	Concretising theory: practice

The Conversational Framework suggests that the significance of adaptive media is reinforced by high values of interactivity, exploration possibilities, and achievements awareness (Venkatesh, Croteau & Rabah, 2014). On the same note, Petko (2012) is of the opinion that adaptive media have higher values of user control and competition as the learner engages with the taught content.

4.4 Data Analysis Tool

After considering all the media forms and the affordances associated with tablets and smartboards, a data analysis tool was developed. This analytical tool was used to understand the relationship between espoused and enacted practice, and track whether there would be pedagogical value if the Tablets and Smartboards are used in teaching and learning of Physical Science. Table 4.6 below presents the data analysis too.

Table 4.6: Data analysis tool

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Productive	Articulation	Animation / Model	Face to face and Remote	Knowledge construction
	Narrative	Non-linear	Multimodality	Face to face	Apprehending structure
	Interactive	Immediacy	Immediate feedback	Remote and face to face	Exploring: misconceptions and amend
	Communicative	Collaboration	Discussion	Face to face class /group	Re-description of concepts
	Adaptive	Diversity	Reproduction: Model/role play	Remote and Face to face	Concretizing theory: practice
Smartboards	Productive	Articulation	Animation / Model	Face to face	Knowledge construction
	Narrative	Non-linear	Multimodality	Face to face	Apprehending structure
	Interactive	Immediacy	Immediate feedback	face to face	Exploring: misconceptions and amend
	Adaptive	Diversity	Reproduction: Model/role play	Face to face	Concretizing theory: practice

First column identifies the ICT Tools used. This research focused only on Tablets and Smartboards as primary ICT tools for teaching and learning of Physical Science. The second column is the media forms associated with each Table (Communicative, Interactive, Narrative, Adaptive, and Productive) and Smartboards (Narrative, Interactive, and Productive). This categorisation is also important to ascertain the related use setting. The affordances of Smartboards and Tablets, based on their physical properties are presented in the third column. The fourth column presents the evidence expected during engagement with ICT tools. In the fifth column represent the learning setting with which the Smartboards and or the Tablets can effectively be used as teaching and learning tools in the context of Physical Science. And the

last column explicit pedagogical value associated with the use of Smartboards and Tablets in teaching and learning of Physical Science.

4.4.1 Aligning the analytical tool

In order to use this analytic tool meaningfully to ascertain the pedagogical value of integrating Smartboards and Tablets in teaching and learning, the analytical tool presents the ICT tools first (Smartboards and Tablets). Thereafter, the analytical tool presents media forms associated with each ICT tool. Each media form results in certain affordances which are presented in the third column. The evidence columns are also added to indicate if Smartboards and Tablets was used or referred to be used with the respective media form during the observed lesson. Also, the use setting column helps to determine whether these ICT tools were used in the observed class or used after class. Finally, the last column helps to determine if these affordances lead to enhancing teaching and learning of Physical Science.

It is through the use of this analytical tool that this research is able to determine usage of Tablets and Smartboards that is of significant pedagogical value when teaching Physical Science. Also, determining whether each tool is of high or low pedagogical value. As a result, it is essential to take level of value proposition as an important analysis factor in order to demonstrate consistency in terms of whether there is value in the use of the ICT tool or not. The following section discusses the analysis and interpretation of the results from the two schools, using the above analytical tool.

4.5 Conclusion

The Conceptual Framework developed in this research has been the centre of reference in making decisions on the best approach to analyze data and extract meanings from the research results. The structure of the framework is largely dependent on the Conversational Framework developed by Laurillard (2012) and the analytical framework developed by Ndlovu (2015). Apart from being the tool for analyzing research data, this framework informed the research design, method, data collections instrument and the empirical and theoretical literature engaged. The next chapter presents the analysis and interpretation of data based on the analytical framework developed for this study.

Chapter Five

DATA PRESENTATION AND ANALYSIS

5.1 Introduction

This chapter presents data that was collected for this study. The data were analysed to understand if there was any pedagogical value in the integration of technology in the teaching and learning of Physical Science at Grade 12. The data collection process comprised of two schools located in the city of Johannesburg, South Africa, and the teachers that teach Physical Science Grade 12. Background checks to determine the level of teacher knowledge on the use of technology in their instructional approach to the subject were conducted through the structured interview process. Furthermore, the data collection activity also included recording the class lesson during the observation of the class while it was in session. The ultimate aim was to collect, analyse and interpret the data in a bid to address the following research questions:

1. What are teacher's perceptions on the pedagogical value of Smartboards and Tablet computers in Physical Science classrooms?
2. What are teacher's enacted practices in the use of Smartboards and Tablet computers for teaching Physical Sciences?
3. How does the use of Smartboards and Tablet computers enhance teaching and learning in high school Physical Science classes?

This research is built on the premises of the Conversational Framework developed by Laurillard (2002), which accepts that teaching is a conversation. Also, Laurillard (2002), postulates that learning can develop through learning activities. In essence, these learning activities provide evidence of the value that Smartboards and Tablets bring to the teaching and learning of Physical Science. Furthermore, Laurillaurd (2012, p.11) states that the Conversational Framework seeks to "evaluate the extent to which the various media support the full specification or pedagogical setup". However, Šumak and Šorgo (2016) believe that teacher attitude, experience, and perceptions influence the learning setting and pedagogical integration of ICT. In this conversation, pedagogical integration of Smartboards and Tablets on teacher enacted and espoused practices are expected to enhance knowledge creation and

sharing. Consequently, the associated pedagogical value is evident from the media forms and the associated affordances of Smartboards and Tablet computers. Ertmer (1999) extends this view and states that the teacher's beliefs influence the extent to which teachers integrate ICTs. To simplify the analysis and interpretation of the results, the analysis tool developed in chapter four will be used to evaluate the relationship between pedagogical integration of Smartboards and Tablets on teacher enacted and espoused practices and the associated pedagogical value.

5.2 Background of the Targeted Schools

The two schools considered in this research carry almost similar status as they are both located in townships. The focus of this study was based on schools that had Smartboards and Tablets from 2015 to 2020. However, these two township schools coincidentally matched the focus of the study. School A is situated in Thembisa on the North East side of Johannesburg. School B lies almost on the Eastern side of Johannesburg but belongs to the same district of Ekurhuleni North. They are in the midst of black communities whose enrolment targets learners around these areas. The two schools were convenient for data collection, they are a good source of information due to the fact that they were privileged with the installation of Smartboards as teaching resources by the government. Physical Science is offered to those learners who are academically gifted who also take Mathematics in their subject choices.

5.2.1 Background of participants

The initial plan of the project focused on grade 10 or 11 and not grade12. The idea was not to disrupt the grade 12's program as they were sitting for their final examinations at the end of the year. Nonetheless, due to unforeseen circumstances precipitated by the emergency of COVID-19, data was collected from grade 12 classes because they were the only group allowed in school. This was in compliance with COVID 19 protocols and guidelines. The grade 12 students are scheduled to take their final Physical Science exam at the end of the year. Students selected and enrolled into the Physical Science class are considered intelligent as they have to meet certain academic criteria. The ages of the students ranged between 17 and 21 years. The profile of the teachers participating in this study is presented in the table below.

Table 5.1: Profile of Respondents

Teacher	Subject taught	School	Teaching Experience	Experience Tablets and Smartboards	Qualification
X	Physical Science	A	27years	5 years	BED Hons Maths & Science
Y	Physical Science	B	19years	5 years	BSc in Physical Science

5.2.2 Teacher perceptions (interview Analysis)

Research has been increasingly interested in how teachers perceive the use of technology in their lesson delivery. Their approach and how they handle the environment has always been under microscopic scrutiny. According to Clark and Peterson (1986), the process of teaching involves two major domains, teachers' thought process, and teachers' actions and their observable effects. It is the teacher's perceived ideas and attitudes that give a positive reception to the infusion of technology in teaching and learning in a Physical Science lesson in particular.

Teacher X's Perceptions on the introduction of Smartboards and Tablets

In 2015, teacher X's school was one of the privileged schools selected by the Department of Education to have Smartboards installed and Tablets given to learners. These technological resources were meant to be used by grade 12 teachers and learners. In his words;

> *This was an exciting experience as most of the paperwork was substituted by these technologies. Also, with an internet connection, we could venture into any world of Science.*

He laments the Department of Education on its poor planning. It took a lot of time for them to be trained to use the gadget. This was an indication portraying the teacher's willingness to adapt to the impending change. However, as more and more workshops were conducted, they got used to how to navigate features on the Smartboard. The availability of Smartboards helped the teachers to venture into teaching materials that relate to the subject of Physical Science. Where materials for an experiment could not be purchased a video of an experiment could be shown on the screen of the Smartboard.

Technicians were not readily available on sight. If ever there was a fault or where areas of clarity were needed, the Department of Education would be called for technicians to come and address the raised concerns. This, however, caused some delays and they were forced to resort to the old system.

Integration of technology in teaching and learning has been blamed on the lack of desire by the teacher. However, in some instances, it is attributed to the lack of support by the education department and administration (Bingimlas 2009). Besides all the challenges faced in getting the knowhow of this technology, the teacher applauded the use of technology as it had immense contribution to the coverage of the annual teaching plan during the period of lockdown caused by COVID-19.

Teacher Y's Perceptions on the introduction of Smartboards and Tablets

The introduction of Smartboards and Tablets technology in 2015 in Teacher Y's school was viewed by Teacher Y as relief from non-digital teaching methods, at that time, the teacher was already aware of the potential advantages offered by the technologies to teaching and learning. The Department of Education had given them training prior to the installation of the Smartboards.

The teacher acknowledged that the training provided simplified the teaching process. Furthermore, teaching aided by technology reduces paperwork. However, the use of these gadgets introduced challenges such as failing to access learning material online and understanding the operational requirements of the devices. This was a result of a lack of experience in using the technology which resulted in a loss of lesson time. As this technology was new to everyone even learners also found it challenging to access the educational portals linked to the subject. At times, learners could use these Tablets for games, music, and other things outside schoolwork.

As more training sessions were rolled out by the Department of Education, device usage and operation became much clearer and easier. The teacher acknowledged that successful technology integration meant, being able to use it to his advantage making learners understand lessons better as compared to not having it at all. The teacher asserted that because of Smartboards, planning became easier as he did not run out of ideas and resources. Furthermore, experiments and other important videos could be downloaded for learners to view.

5.3 Pedagogical Value based on teachers' Espoused Practice

This section discusses the pedagogical value of the interview participants, based on their espoused practice. It is also important to understand the beliefs regarding the pedagogical values of Smartboards and Tablets before we analyse how they integrate these technologies in the actual teaching and learning setting. Hence, this section unfolds as follows.

5.3.1 Teacher X's espoused practice

In his espoused practice, Teacher X illuminates the learning needs for Physical Science, and how Smartboards and Tablets activate learning. In his account, Teacher X confidently supports the usefulness of Smartboards, not only as learning aids but as tools to help learners to stay motivated and focused throughout the lesson time. On the same note, the teacher believes that motivated and focused students pay attention to every detail that the teacher puts across, which he believes is precedence to learning. On the other hand, the teacher comments on the learners' response to the two technologies as follows;

> *For the majority of the learners, it has transformed their behaviour for better because one can see their enthusiasm in using the technology but for a few, their behaviour has not changed. They see technology as resources for entertainment.*

This statement suggests that Smartboards and Tablets have an impact beyond the creation and transfer of knowledge. In essence, these technologies have a positive effect on the behaviour of learners towards learning. However, some learners do not view Tablets as educational tools, and thus, they would become disruptive to learning.

- Narrative

The teacher laments the challenges that the school went through in terms of sourcing materials needed to conduct experiments. On that note, the teacher believes that the introduction of Smartboards and Tablets enables them to effectively plan for lessons, and substitute some learning resources with videos. In his words, the teacher states that;

> *The videos can be downloaded and forwarded to learners' tablets where they view and analyse at their own convenient time.*

This statement also suggests that the teacher`s belief in visual properties afforded by Tablets and Smartboards worked well in presenting content in Tablets. Table 5.2 below provides a summary of the narrative media forms based on the results from Teacher X espoused practice.

Table 5. 2: Summary of narrative media forms (Teacher X's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Narrative	Non-linear *Use a portfolio of affordances*	Multimodality *Use multimodal Text, visuals and audio*	Face to face And Remote	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*
Smartboards	Narrative	Non-linear *Use a portfolio of affordances*	Multimodality *Use multimodal Text, visuals and audio*	Face to face	Apprehending structure *Use multimodal text, visuals and audio to simulate real-life experience thus enhancing comprehension.*

- Interactive

Teacher X applauds the significance of Tablets in the classroom, especially when students interact with the learning materials in student portals. On the other hand, he raises concerns with regard to inadequate training that leads to misuse of the Tablet. In his words, he attests that;

> *As this technology was new to everyone even learners also found it challenging to access the educational portals linked to the subject. Out of frustration, learners ended up using these Tablets for games, music and other things outside school work.*

In essence, if learners effectively use these technologies, the creation and transfer of knowledge between teachers and learners will be enhanced. Thus raising the pedagogical value of Smartboards and Tablets. Although Teacher X raises concerns relating to skills and competencies of using these technologies for teaching and learning, he is also positive and believes that the use of Tablets is transforming how he delivers his lessons, students come to class well prepared and they ask questions and engage in class discussions with great confidence. The following table summarises narrative media forms based on the results from Teacher X`s espoused practice.

Table 5. 3: Summary of interactive media forms (Teacher X's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Interactive	Immediacy *Easy navigation when presenting in class, Quick submission of tasks (portal / email)*	Immediate feedback *Quick submission of tasks and providing feedback*	Remote and face to face *Class and Take home tasks*	Exploring: misconceptions and amend *Immediate feedback enables quick correction of misconception and wrong answers*
Smartboards	Interactive	Immediacy *Easy navigation when presenting in class and Learner class demonstration*	Immediate feedback *Quick intervention*	Face to face *Class demonstrations*	Exploring: misconceptions and amend *Provide immediate visual display that can be modeled to give further clarification and correction of misconceptions*

- Adaptive

What teacher X says regarding the use of Tablets for practicing after class seems to attract interest to establish whether the pedagogical value of these Tablets could expand beyond the classroom environment. In essence, it is evident from the teacher`s assertion that Tablets facilitate experimentation and practice when teaching Physical Science classes. Also, it is important to acknowledge teacher X`s position that the use of Tablets enhances his teaching as he can integrate theory and practice through the adaptive capabilities of Tablets, such as is colour coding, writing, and manipulating formulas among other features.

> *Where materials for an experiment could not be purchased a video of an experiment could be shown on the screen of the Smartboard*" (Appendix 12, Q9).

The following table summarises adaptive media forms based on the results from Teacher "X"`s Espoused Practice.

Table 5.4: Summary of adaptive media forms (Teacher X's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Adaptive	Diversity *Adopting designs that can be transformed to suit teaching and learning needs of learners*	Reproduction: Model/role play *Use of drawings and other artistic features to enhance learning*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *Consolidating theoretical knowledge through practice with the Tablets applications.*
Smartboards	Adaptive	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Communicative

In his espoused practice, Teacher X uses the messaging capabilities of the Tablets to encourage group work and communicating with other group members. Although Teacher X believes that learners can benefit more from group activities, he is also skeptical of the usefulness of these virtual groups as learners end up discussing non-school-related topics. Furthermore, he believes that the successful integration of Smartboards and tables enhances engagement, participation, and exchange of information.

> *A successful integration of technology with the classroom can be a great way of strengthening the engagement and participation of learners. And Being able to send learners updates through WhatsApp and email.*

While the teacher believes that tablets enhance communication with learners after class, they are also not used properly for the benefit of the learners. To minimise abuse of such communication channels, teacher X suggests using a third-party application to limit or block non-academic applications on Tablets supplied by the school. Although this method could help to monitor students, this might also discourage learners from using Tablets altogether. The following table summarises communicative media forms based on the results from Teacher X's espoused practice.

Table 5.5: Summary of communicative media forms (Teacher X's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Communicative	Collaboration *Group tasks and presentation*	Discussion: *Group work and presentation through virtual applications like email and messaging Apps*	Remote and Face to face *Class and virtual group work*	Re-description of concepts: *Empower learners with analytical, and critical thinking skills, analysis of facts to form a judgment.*
Smartboards	Communicative	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Productive

Although Teacher X believes that Smartboards do not have the capability to equip learners individually with their modelling capability, he also believes that it indirectly assists learners who learn by doing especially through in-class demonstrations. Also, teacher X believes that

learners who partake in challenges during demonstrations motivate other learners to use the modelling capabilities of the smartboards in a classroom setting. Referring to the account that Teacher X provided, it is evident that both Smartboards and Tablets allow learners to produce meaningful outcomes. However, learners seem to be more familiar with non-academic applications compared to academic applications (Word processors, Power-Point, Email, etc.) Teacher X is in support of adopting non-academic applications such as social media applications to enable learners to communicate, create, edit, and share media in group discussions. Ultimately, the pedagogical value of Smartboards and Tablets is evident in their ability to allow learners to model and enhance learning through the use of productive media such as word processors and emails. The following table summarises Productive media forms based on the results from Teacher "X's" espoused practice.

Table 5.6: Summary of productive media forms (Teacher X's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Productive	Articulation *Individual and group take home tasks for submission*	Animation / Model *Use of productive media such as word processors and emails*	Remote *Work from home practice*	Knowledge construction: *Empowering students to practice physical science using Tablet applications*
Smartboards	Productive	Articulation *Teacher, Group and Individual, Demonstrations*	Animation / Model *Drawing of tables and charts*	Face to face: *Class demonstrations*	Knowledge construction: *Empowering students to role model, use interactive design features to model and explain concepts*

5.3.2 Teacher Y's espoused practice

In his espoused practice, Teacher Y strongly believes that Tablets bring more value to learning as compared to Smartboards. Nevertheless, he argues that Smartboards and Tablets complement each other in lesson delivery. More so, Teacher Y believes that the manner in which he sets up his classes enables learners to feel comfortable using Tablets. It is also evident that the teacher appreciates learning in a natural setting, that is, the environment conducive for the introduction of these technologies, because it gives learners that flexibility which he needs to encourage interaction with the learning devices. Table 5.7 presents the analysis of Teacher Y's Espoused Practice

- Narrative

The teacher believes that teaching Physical Science requires a lot of demonstrations and concrete examples. Also, he illuminates that learners understand better with visuals and that they easily comprehend subject content in cases where the teacher cannot give physical examples or physical demonstrations. In his words, the teacher testifies that;

> *We can't experiment because of lack of equipment and chemicals, we just download lesson videos, and watch the experiment on the Smartboard, and learners can also download it into their tablets and smartphones and watch it later on. I have been using this method for some time now and it makes teaching simple.*

This piece of information also suggests that the teacher`s belief in visual properties afforded by Smartboards and Tablets is greatly influenced by his understanding, knowledge, and experience of teaching Physical Science. The following table summarises interactive media forms based on the results from Teacher Y's espoused practice.

Table 5.7: Summary of narrative media forms (Teacher Y's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Narrative	Non-linear *Use a portfolio of affordances*	Multimodality *Use multimodal Text, visuals and audio*	Face to face And Remote	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*
Smartboards	Narrative	Non-linear *Use a portfolio of affordances*	Multimodality *Use multimodal Text, visuals and audio*	Face to face	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*

- Interactive

Although Teacher Y believes that the use of Tablets is hampered by the technical skills and behaviour of students, he is fully convinced that the success of Tablets for learning purposes requires learners to be oriented on how to use them. He commented that Tablets give immediate access to content, which in turn quickens the feedback process.

> *Given the way, I'm now used to technology; it is becoming a problem to finish up my lesson without the use of it. For example, the smartboard is everything in one, from demonstrations; research, getting extra resources to writing notes on it* (Appendix 13).

However, Teacher Y did not fully provide details on how he integrates the use of Smartboards and Tablets in teaching Physical Science. As a result, it is imperative to analyse data from

classroom observations. The following table summarises interactive media forms based on the results from Teacher Y's espoused practice.

Table 5.8: Summary of interactive media forms (Teacher Y's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Interactive	Immediacy *Easy navigation when presenting in class, Quick submission of tasks (portal / email)*	Immediate feedback *Quick submission of tasks and providing feedback*	Remote and face to face *Class and Take home tasks*	Exploring: misconceptions and amend *Immediate feedback enables quick correction of misconception and wrong answers*
Smartboards	Interactive	Immediacy *Easy navigation when presenting in class and Learner class demonstration*	Immediate feedback *Quick intervention*	Face to face *Class demonstrations*	Exploring: misconceptions and amend *Immediate visual display that can be modeled to give further clarification and correction of misconceptions*

- Adaptive

Teacher Y believes that Physical Science learners need to receive formal orientation so that they understand the importance of working independently with their Tables at home, and asking questions through instant messaging channels. The teacher acknowledged that a countable number of learners who have personal Tablets perform well in both demonstrations and experiments because they work independently to master Physical Science concepts and practice prior to attending classes.

> *Learners can play science games like 3D brain and Science Journal by Google. There are more games that help learners to experiment on their own comparing their results* (Appendix 13).

Similar to teacher Y, verifying these provisions may prove challenging since observations were only conducted during class time. The following table summarises adaptive media forms based on the results from Teacher Y's espoused practice.

Table 5.9: Summary of adaptive media forms (Teacher Y's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Adaptive	Diversity *Adopting designs that can be transformed to suit teaching and learning needs of learners*	Reproduction: Model/role play *Use of drawings and other artistic features to enhance learning*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *Consolidating theoretical knowledge through practice with the Tablets applications.*
Smartboards	Adaptive	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Communicative

Teacher Y sees the communicative capabilities of Smartboards differently. He is of the opinion that the communicative affordances of tablets provide an inroad to considering habitual use of technologies. He also believes that teaching is made easier when the teacher can trace the habits of learners by checking response time in terms of classwork and assignments given. In his words, the teacher gives examples of elements that need tracking;

> *As teachers, we must be able to see when learners use technology on school work and other things. The information they share using school devices. For example, media download statistics, the number of times learners go on the portal to access resources and the number of times learners read announcements and respond on discussion forums* (Appendix 13).

Apart from monitoring learners' communication using Tablets, Tablet use in classrooms help to establish students` habits when using them for learning purposes. The following table summarises communicative media forms based on the results from Teacher Y's espoused practice.

Table 5.10: Summary of communicative media forms (Teacher Y's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Communicative	Collaboration *Group tasks and presentation*	Discussion: *Class and group presentation through virtual applications like email / portal*	Remote and Face to face *Class and virtual group work*	Re-description of concepts: *Empower learners with analytical, and critical thinking skills, analysis of facts to form a judgment.*
Smartboards	Communicative	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Productive

In his espoused practice, Teacher Y uses a limited assortment of applications with learners even though he believes that tablets have the capability of handling a variety of media types. In essence, Teacher Y suggests that researchers should look into ascertaining the most applicable applications in the context of teaching Physical Science. He believes that the Tablets that the learners were given have limited applications like a word processor, and presentation media properties. Also, he suggests that these tablets should have more interactive application that could allow learners to produce results which they can present in class or as part of an assessment. The following table summarises Productive media forms based on the results from Teacher Y's espoused practice.

Table 5.11: Summary of productive media forms (Teacher Y's espoused practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Productive	Articulation *Engagement of different concepts during and after class*	Animation / Model *Use of productive media such as word processors, emails and PowerPoint*	Remote *Class and Take home tasks*	Knowledge construction: *Enhance teacher demonstrations and empower students to practice*
Smartboards	Productive	Articulation *Teacher, Group and Individual, Demonstrations*	Animation / Model *Drawing of tables and charts*	Face to face: *Class demonstrations*	Knowledge construction: *Empowering students to role model, use interactive design features to model and explain concepts*

The analytical tool worked well as a lens to expose that which is of pedagogical value when using Smartboards and Tablets during the teaching of Physical Science. It is through the

analytical tool that this study can determine usage that is of significant pedagogical value and that which is of low pedagogical value. It is important to take note of this factor to demonstrate consistency that has something to do with whether there is value in the use.

5.4 Teacher Enacted Practices (lesson observations)

The researcher took time to be a passive learner in both the classes of the chosen teachers. The aim was to observe how the teachers use the Smartboard technology in their lesson delivery and synchronising it with the Tablets. To ascertain the pedagogical value of Smartboards and Tablets the following section presents the analysis of observed teaching and learning patterns with Tablets and Smartboards.

5.4.1 Lesson observation Teacher X

Topic: Chemical Equilibrium (Lechatelier's Principle)

ICT used by Teacher: Laptop and Smartboard

ICT used by Learners: Tablets

Overview of the lesson

There was a show of confidence by this teacher on the use of the Smartboard. He displayed skill when he introduced his topic. His skills regarding the use of computers and Smartboards seemed to be advanced. Therefore, it is logical to acknowledge that the knowledge of using a computer could be attributed to the quick understanding of using the Smartboards. The lesson was a continuation of a topic that was started three days before the observation. The topic was Chemical Equilibrium, which demands a lot of explanation and demonstration and can be challenging to learners if resources (equipment for experiments, demonstration videos, and media streaming devices) are not availed. This particular day he was teaching the concept of Lechatelier's principle. With the use of diagrams and videos downloaded from the internet, it was clear that the learners understood much better than a mere explanation from the teacher. This was evident from the way in which learners were quickly responding to random questions that the teacher was asking during the lesson. For instance, the teacher asked a random question;

Teacher: What happens to the volume when we increase the pressure?

Five students raised their hands at once to give their responses.

Student 1: when we increase the pressure the volume decreases

Student 2: pressure forces particles to fit in a small space, so more particles fit in a small volume.

The teacher asked if other students agree and they all said 'yes'.

Based on these reactions, it is evident that the integration of Smartboards in teaching and learning through the use of visual displays to explain concepts has a positive impact on learning. This also suggests that when teachers upload the videos on the portal, learners can learn at a faster pace by merely watching videos. In essence, the visual affordances of Smartboards and Tablets have a significant value towards teaching and learning Physical Science. The classroom setup for teacher X enabled an undistracted view of the visuals as the teacher conduct classes. Figure 5.1 presents the classroom presentation setup for Teacher X.

Figure 5.1: Class Presentation Teacher "X"

5.4.2 Lesson observation Teacher Y

Topic: Electrolysis of Cells

ICT used by Teacher: laptop and Smartboard

ICT used by Learners: Tablets

The teacher started with an explanation of the background of Electrolysis of cells. The topic was on the types of Electrochemical cells. The whole lesson was presented on PowerPoint. Prior planning was evident as he picked a point on each slide and elaborated on it. What made the lesson more interesting was the video and pictures which were embedded in the slides. The teacher would pose and allow learners to watch the video which further helped to explain some of the key concepts. As the teacher proceeded with the explanation highlighting important concepts on the visual display, some learners used his tablet to capture the Smartboard screen.

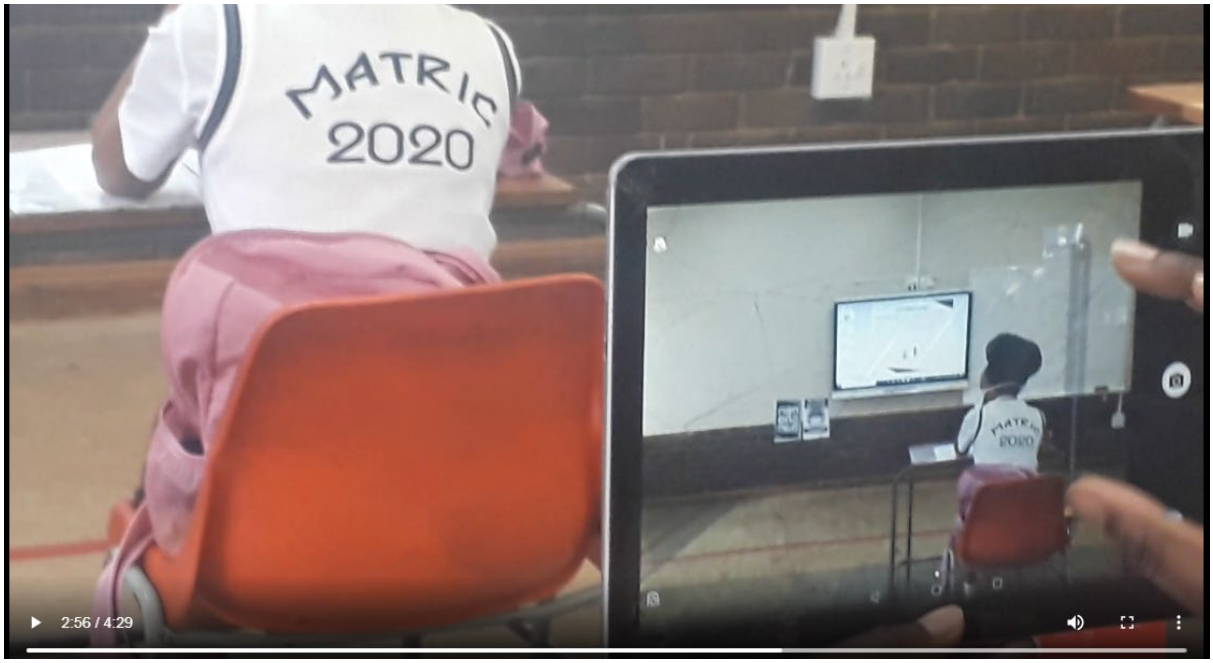

Figure 5.2: Learner Taking Screenshots

Teacher Y allowed learners to listen and not write as the slides and other information for the lesson would be posted on their Tablets. The teacher would pose to allow learners to highlight areas of concern or misunderstanding. Clearly, the use of the video and some diagrams not found in the textbook generated a lot of interest to the learners. As he concluded the lesson, a class activity was uploaded together with the lesson presentation on their Tablets.

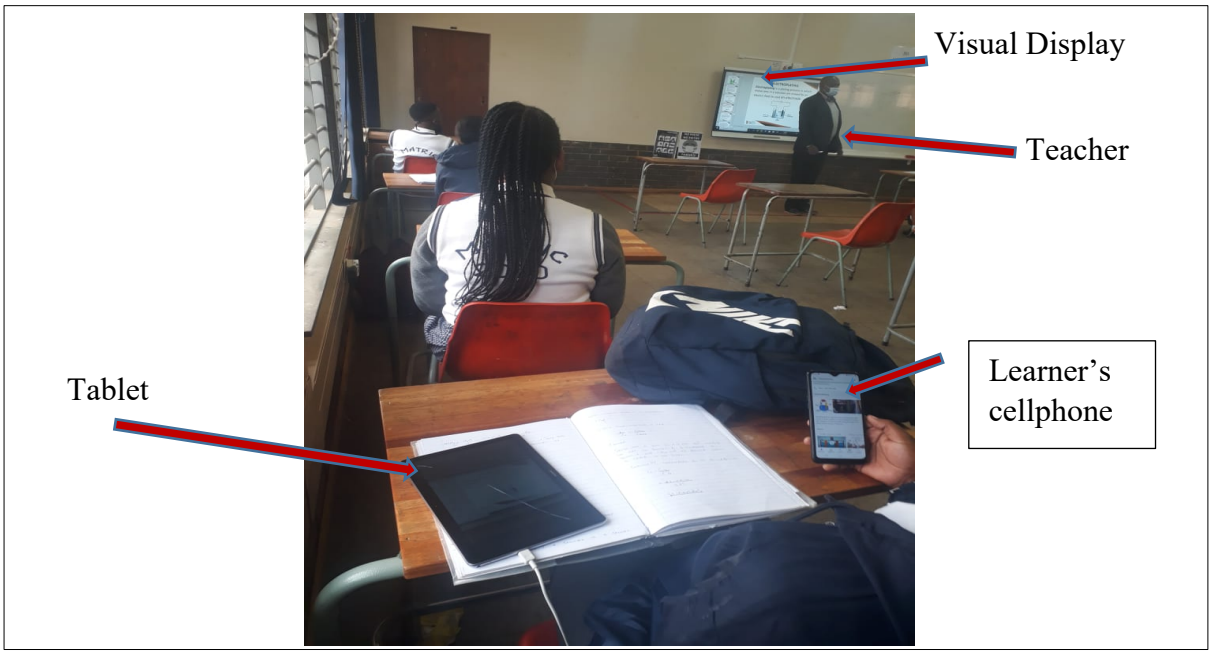

Figure 5.3: Class Presentation Teacher Y

5.5 Learners' Behaviour (lesson observation analysis)

In both classes, there was great enthusiasm from the learners, visible from their reactions and participation. The videos and images drew much attention evident from the level of concentration and participation. There was excitement as the lessons were uploaded to their Tablets. In addition, one of the learners used his cellphone to search on the subject taught.

5.6 Pedagogical Value based on Teachers' Enacted Practice

Although the research gathered a significant amount of information through the interviews, they are mostly their own classroom experiences and perceptions of pedagogical value. To gain a more concrete understanding of the pedagogical value of Smartboards and Tablets in their enacted practice, observational techniques were employed to observe student behaviour and class delivery by teachers. Therefore, this section discusses the pedagogical value based on the observation of the subjects in their actual teaching environment (enacted practice). In essence, this analysis will also add to an understanding of how teachers integrate Smartboards and Tablets in their actual teaching and learning environment. Henceforth, the following subsection discusses the enacted practice on Teacher X.

5.6.1 Teacher X enacted practice

- Narrative media forms

In his enacted practice, Teacher X uses diagrams and videos downloaded from the internet, to enhance the explanation of Physical Science concepts and content. This symbolises the importance of Smartboards and Tablets to afford narrative media forms. Basing the analysis of the class observation, it was clear that the learners comprehend much better, video enhances explanation than a mere verbal explanation from the teacher. A summary of narrative media forms for Teacher X is presented in table 5.12 below.

Table 5.12: Summary of narrative media forms (Teacher X's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Narrative	Non-linear *Use a portfolio of affordances to simplify subject content.*	Multimodality *Use multimodal Text, visuals and audio to simplify subject content.*	Face to face And Remote *Class and Take home tasks*	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*
Smartboards	Narrative	Non-linear *Use a portfolio of affordances to simplify subject content.*	Multimodality *Use multimodal Text, and visuals to simplify subject content.*	Face to face	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*

- Communicative media form

During the lesson, the teacher could make deliberate pauses to allow learners to highlight areas of concern and additional questions which they should send to the teacher through the messaging application and email. These questions would then be considered for further clarification and would form part of the first activity at the beginning of the next class session. This signifies the communicative capability of Tablets. A summary of communicative media forms for Teacher X is presented in table 5.13 below.

Table 5.13: Summary of communicative media forms (Teacher X's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Communicative	Collaboration *Group work (peer to peer) and class presentation (Teacher to Learner)*	Discussion: *Learner to learner on class and virtual activities. Teacher engagement over virtual display Applications*	Remote and Face to face *Class and virtual group work*	Re-description of concepts: *Empower learners with analytical, and critical thinking skills, analysis of facts to form a judgment. And concept learning*
Smartboards	Communicative	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Interactive media form

Since learners have access to pictures and diagrams on their Tablets, the teacher would stop in the middle of the session and ask learners to identify and explain the contents of the picture. The teacher would then poll the students on whether they agreed or disagreed with responses provided by other students. During the entire class session, the teacher was asking learners to make notes on the content shared over the internet. Thus allowing students to adjust and simplify the content to the level of their understanding. A summary of interactive media forms for Teacher X is presented in table 5.14 below.

Table 5.14: Summary of interactive media forms (Teacher X's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Interactive	Immediacy *Immediate availability of different learning approached for learning physical science*	Immediate feedback *The quality of feedback is dependent on the teaching method used*	Remote and face to face *Class and Take home tasks*	Exploring: misconceptions and amend *Interaction between learners and between teachers and learner is enhanced by through the use of different teaching and learning approaches used.*
Smartboards	Interactive	Immediacy *Instant and smooth shift from one concept component to the next*	Immediate feedback *Immediate feedback promote immediate intervention*	Face to face *Class demonstrations*	Exploring: misconceptions and amend *Teacher uses feedback to give further clarification and correct mistakes*

- Productive and Adaptive media form

Throughout the class, the students pay undivided attention to the teacher. Also, Teacher X gives short tutorial quizzes to check the progress of student's understanding of the content that he is teaching. At the end of the class, he also informs learners about the tutorial questions that the learners have to do after class. In his enacted practice, Teacher X asks learners to submit electronic copies of their tutorials, which could express how they managed to synthesise the theory they learnt to create scientific objects and the accompanying texts. A summary of productive and adaptive media forms for Teacher X is presented in table 5.15 below.

Table 5.15: Summary of productive and adaptive media forms (Teacher X's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Productive	Articulation *Brings in different problem solving techniques*	Animation / Model *Using different affordances to simplify teaching and learning*	Remote *Class and Take home tasks*	Knowledge construction: *Use of a variety of techniques facilitate adoption of a mix of teaching and learning methods*
Smartboards	Productive	Articulation *Brings in different problem solving techniques*	Animation / Model *Using different affordances to simplify teaching and learning*	Remote *Class and Take home tasks*	Knowledge construction: *Use of a variety of techniques facilitate adoption of a mix of teaching and learning methods*
Tablets	Adaptive	Diversity *Adopting varied designs that can be manipulated to suit teaching and learning needs of learners*	Reproduction: Model/role play *Use of drawings and other artistic features to enhance illustration of concepts*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *Consolidating theoretical knowledge through conceptualization of abstract concepts.*
Smartboards	Adaptive	Diversity *Adopting different teaching approaches to suit learners' needs*	Reproduction: Model/role play *Different teaching approaches to suit learners' needs*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *A mix of different teaching strategies allows learners to choose the learning approach that works better for them*

5.6.2 Teacher Y's enacted practice

- Narrative media forms

Just like Teacher X, Teacher Y use diagrams and videos downloaded from the internet, to enhance the explanation of physical science concepts and content. In addition to the media, the

teacher also asks students to watch other related videos from the internet and share what they learnt with other learners during the lesson. In principle, this suggests that Tablets and Smartboards do assist to explain, demonstrate and describe scenarios to simplify subject content. Basing on the excitement which learners showed when they are asked to present in class, it is evident that learners appreciate searching for additional visual media to enhance their understanding of the course content in addition to what teachers provide in class. A summary of narrative media forms for Teacher Y is presented in table 5.16 below.

Table 5.16: Summary of narrative media forms (Teacher Y's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Narrative	Non-linear *Use a portfolio of affordances to simplify subject content.*	Multimodality *Use multimodal Text, visuals and audio to simplify subject content.*	Face to face And Remote *Class and Take home tasks*	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*
Smartboards	Narrative	Non-linear *Use a portfolio of affordances to simplify subject content.*	Multimodality *Use multimodal Text, and visuals to simplify subject content.*	Face to face	Apprehending structure *Use multimodal text, visuals and audio to simulate real life experience thus enhancing comprehension.*

- Communicative media form

Apart from verbal communication between the teacher and the learners, Smartboards promote interaction between the teacher and the learners through visual representation. A learner who was seated at the back of the classroom was asked whether she heard what the teacher said, in response she said

> *I couldn`t hear clearly but I understood the context because the words were clearly visible on the visual display.*

In essence, it is evident that in Teacher Y`s case, visual display plays an important role in the understanding of Physical Science concepts. A summary of communicative media forms for Teacher Y is presented in table 5.17 below.

Table 5.17: Summary of communicative media forms (Teacher Y's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Communicative	Collaboration *Group work (peer to peer) and class presentation (Teacher to Learner)*	Discussion: *Learner to learner on class and virtual activities. Teacher engagement over virtual display Applications*	Remote and Face to face *Class and virtual group work*	Re-description of concepts: *Empower learners with analytical, and critical thinking skills, analysis of facts to form a judgment. And concept learning*
Smartboards	Communicative	Collaboration *None*	Discussion: *None*	Face to face *None*	Re-description of concepts *None*

- Interactive media form

The class proceeded smoothly with all indications of prior planning. Learners were following as the teacher interacted with the visual display so that it presents his teaching in a simpler format. Also, the teacher could adjust the content of the PowerPoint presentation, adding simplified notes to the content. While teaching, Teacher Y was discouraging learners from writing while speaking citing that the content will be uploaded on their Tablets. A summary of communicative media forms for Teacher Y is presented in table 5.18 below.

Table 5.18: Summary interactive media forms (Teacher Y's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Interactive	Immediacy *Immediate availability of different learning approached for learning physical science*	Immediate feedback *The quality of feedback is dependent on the teaching method used*	Remote and face to face *Class and Take home tasks*	Exploring: misconceptions and amend *Interaction between learners and between teachers and learner is enhanced by through the use of different teaching and learning approaches used.*
Smartboards	Interactive	Immediacy *Instant and smooth shift from one concept component to the next*	Immediate feedback *Immediate feedback promote immediate intervention*	Face to face *Class demonstrations*	Exploring: misconceptions and amend *Teacher uses feedback to give further clarification and correct mistakes*

- Productive and Adaptive media form

Although it was not clear that Teacher Y used adaptive media forms, class exercises did facilitate experimentation and practice. Also, the teacher gave take-home exercises that he could use to measure student`s understanding of concepts. Similar to teacher X`s class, -

Teacher Y requested learners to submit their typed homework electronically. In this typed homework, learners were using the modelling capabilities of Tablets to create responses to homework questions. A summary of productive and adaptive media forms for Teacher Y is presented in table 5.19 below.

Table 5.19: Summary of productive and adaptive media forms (Teacher Y's enacted practice)

ICT Tools	Media Forms	Affordances	Evidence	Use Setting	Associated Pedagogical Value
Tablets	Productive	Articulation *Brings in different problem solving techniques*	Animation / Model *Using different affordances to simplify teaching and learning*	Remote *Class and Take home tasks*	Knowledge construction: *Use of a variety of techniques facilitate adoption of a mix of teaching and learning methods*
Smartboards	Productive	Articulation *Brings in different problem solving techniques*	Animation / Model *Using different affordances to simplify teaching and learning*	Remote *Class and Take home tasks*	Knowledge construction: *Use of a variety of techniques facilitate adoption of a mix of teaching and learning methods*
Tablets	Adaptive	Diversity *Adopting different teaching approaches to suit learners' needs*	Reproduction: Model/role play *Different teaching approaches to suit learners' needs*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *A mix of different teaching strategies allows learners to choose the learning approach that works better for them*
Smartboards	Adaptive	Diversity *Adopting different teaching approaches to suit learners' needs*	Reproduction: Model/role play *Different teaching approaches to suit learners' needs*	Remote and Face to face *Class and Take home tasks*	Concretizing theory and practice: *A mix of different teaching strategies allows learners to choose the learning approach that works better for them*

5.7 Summary on Enacted and Espoused Practices

This research used two different methods of collecting data, which are classroom observations and in-depth interviews. As a result, it is imperative to triangulate the results of the two methods to confirm whether the Pedagogical value of Smartboards and Tablets are evident in both espoused and enacted practice. Based on the results of the research, there is a consensus between what teachers perceive in their espoused practice and what they do in their enacted practice. Both teachers perform with confidence, becoming role models to their learners who take initiative to solve problems rather than putting up barriers to progress. These teachers are hardworking and bring a certain level of energy to their teaching. In the process, they create a sense of perseverance and determination in their classrooms. In both observations, the teachers

encouraged active learning by sharing talk time with students, thus encouraging them to be open-minded, and focused. It was interesting in some cases to see them using their personal devices (cellphones) to extend their learning during the lessons. Overall, the integration of Smartboards and Tablets in teaching and learning in relation to this study proves to have a positive impact. As a result, it is logical to acknowledge the pedagogical value of Smartboards and Tablets in teaching and learning physical science.

Chapter Six

THE VALUE OF TEACHERS' INTEGRATION OF TABLETS AND SMARTBOARDS INTO TEACHING

6.1 Introduction

The preceding chapter provided a detailed analysis and interpretation of data. This chapter discusses, the interpretation of teacher espoused and enacted practice to identify aspects of the results that can assist to describe the pedagogical value of Tablets and Smartboards in teaching and learning Physical Science. This discussion is important to understand the extent to which the integration of Smartboards and tablets in teaching subjects can be standardised to most South African Physical Science classes. Also, the chapter will bring forth insights on how teacher-only resources like Smartboard can be used effectively to enhance teaching and Learning of Physical Science since learners largely lack direct access to Smartboards in classrooms. In essence, learners can benefit immensely from their teachers' effective use of these Smartboards. For this reason, this research sought to unveil how the pedagogical value of Tablets and Smartboards in teaching and learning physical science is evident by examining the relationship between teachers` espoused and enacted practice.

6.2 Main Findings

The following section presents conclusions on teacher X's and teacher Y's practice after making a comparison between the teachers' espoused and enacted practice. In essence, the teacher`s espoused practice informs their enacted practice as suggested by (Ertmer et al., 2012; Breen, 2018). As a result, a comparison between their enacted and espoused practice gives a clear indication of how they integrate Smartboards and Tablets in teaching and learning Physical Science. The interpretation of these conclusions is informed by the analytical tool used in Chapter five. Subsequently, the section discusses the summarized findings of the relationship between the espoused and enacted practice and the pedagogical value identified.

6.2.1 Main findings on Teacher X

The following section presents inferences on Teacher X's practice after making a comparison between the teachers' espoused and enacted practice. Table 6.1 below presents a summary of the results.

Table 6.1: Teacher X Summary of Findings

Media Forms	Espoused		Enacted	
	Evidence of Pedagogical Value	**Key**	**Evidence of Pedagogical Value**	**Key**
Productive	Knowledge construction: Articulation, Animation / Model	TU	Knowledge construction: Articulation, Animation / Model	TU
Narrative	Apprehending Structure: Non-linear, Multimodality	SU, TU	Apprehending Structure: Non-linear, Multimodality	SU, TU
Interactive	Exploring: misconceptions and amend, Immediate feedback	SU, TU	Exploring: misconceptions and amend, Immediate feedback	SU, TU
Communicative	Re-description of concepts: Collaboration, Discussion	TU	Re-description of concepts: Collaboration, Discussion	TU
Adaptive	Concretizing theory and practice: Diversity, Reproduction	SU	Concretizing theory and practice: Diversity, Reproduction	SU

The key for reading each teacher's summary table is presented as follows:

> *SU: Smartboard used, TU: Tablets used, NSTU: No Tablets or Smartboard used, NDT: Non-digital technology used, NONE: No media form*

The table above depicts teacher X's strong belief in the value of Smartboards and Tablets the same as in actually using them in his teaching practice. Particularly in his teaching, he uses Smartboard`s narrative media forms to do video presentations, thus helping him to simplify concepts to visual learners. Although the teacher did not directly use the Tablets to deliver the class presentation, he referred to Tablets when he asked learners to download content from the portal to their tablets for review after class. Also, he poseed in between presentations to allow learners to capture screenshots of the presentation using their Tablets. Finally, he tasked learners to do homework which the learners submited through emailing features from their tablets. In principle, this analysis concurs with Ertmer et al. (2012) claim that "the pedagogical beliefs of teachers have a strong influence on actual teaching". As stated by Laurillard

(2002:16), the use of different platforms to initiate learning exposes learners to "go beyond the specific experience, to offer the symbolic representation that allows the learner to use their knowledge in an unfamiliar situation". As a result, it is logical to conclude that Tablets and Smartboards have a strong pedagogical value in terms of teaching Physical Sciences in the context of Teacher X's espoused and enacted practice.

The teacher provided room for learners to engage with productive media forms. Also at the teacher level, Teacher X engaged with the productive media form, which is a clear indication that the teacher perfectly aligned his espoused practice with the enacted practice. The teacher was also confident when modelling at the teacher level. He believed that his presentation and all its perfections and imperfections models what learners should do when they create and share their knowledge, either in group presentations or knowledge construction in group tasks. Since Teacher X's enacted practice is aligned to his beliefs, this gave a sense of trust in his ability to transform learners with technical, cognitive skills, and analytical skills needed for knowledge construction, be it in a group or individual presentation. In essence, productive media form is of pedagogical value in teaching and learning of Physical Science.

In his espoused practice, Teacher X clearly described his engagement of the narrative form, as well as how Tablets and Smartboards have been a source of inspiration when teaching Physical Science. Apart from his teaching needs, the teacher further described how Tablets and Smartboards can be used together in order to cater to learners' diverse subject needs. Although the school prides itself on language literacy, learners struggle to understand subject-specific jargon, which makes it difficult for these learners to understand the subject content. However, the integration of different technologies and a mix of different narrative media, Smartboards, and Tablets use appears to be useful in teaching and learning Physical Science. To engage all learners, the teacher used a conventional approach to teaching that incorporated speech, written text on the whiteboard, pictures, and video. In essence, the use of a portfolio of affordances to simplify subject content, and apprehending structure through multimodal text, visuals, and audio to simulate real-life experience enhances comprehension. Thus suggesting that Tablets and Smartboards are of pedagogical value towards teaching and learning Physical Science.

In his interactive medium form Teacher X showed great appreciation to the capability of the Tablets for giving instant feedback to learners on tasks that he gave them to do after class. In his enacted practice, there was no room to verify how these automated tests are marked and how the learners react to the instant feedback because all this happens after class. The assumption remained that learners' experience with these assessments is part of learning, and

it is logical to acknowledge that the interactive capabilities of the Tablets are of pedagogical value to teaching and learning of Physical Science. In his enacted practice, Teacher X's interaction with learners is such that it allows learners to air out their misconceptions, asking questions, and responding to questions. Although what the learners say is not directly a result of the influence of Tablets and or Smartboards, they are using these tools to expedite their understanding of concepts and become courageous to ask questions. Therefore, it becomes clear that Tablets and Smartboards are of pedagogical value cantered on the analytical tool developed for this study.

Teacher X expressly applauds the significance of the communicative media form in his espoused practice. He equally used communicative media forms in the actual learning process and it seemed to be very collaborative. Although it may be difficult to establish the source of motivation that the learners showed, it may be rational to acknowledge that the learning setting, the teaching resources, and the teacher`s confidence in using Smartboard and Tablets to deliver classes could be the source of motivation. In the enacted practice, the learners collaboratively worked together with the teacher in retrieving stored information from the portal, giving reference to the key areas that the teacher emphasised. More so, the extent of participation by learners was substantial. As a result, it is safe to say communicative media is of pedagogical value in teaching and learning of Physical Science, evident from re-description of concepts, empowering learners with analytical, critical thinking skills, analysis of facts to form a judgment, and on concept learning.

Teacher X's engagement of Smartboards and Tablets to embed adaptive media form is highlighted in the teacher's espoused practice. He is of the opinion that lesson plans and material designs determine the learning setting. Conforming to this notion, his enacted practice promotes issues of diversity. His use of different teaching tools also engaged learners who preferred learning through a portfolio of methods. In his enacted practice Teacher X makes the integration of different teaching tools clear starting with how the presentation slides are designed. Hence, making it easy for the teacher and the learners to concretise theory and practice, through the use of a mixture of different teaching strategies. Thus providing a proxy for learners to choose the learning approach that works better for them. More so, drawings and animations are integrated into the lesson plan to assist learners to get precise knowledge on how graphs are drawn and interpreted so that they practice with their Tablets. It is important to note that Teacher X's enacted practice helped learners in developing thinking skills following the teacher`s engagement with these adaptive features of the Smartboard. Therefore,

it is evident that Smartboards and Tablets add value to the teaching and learning of Physical Science.

Conclusion

From the review of the results, it is evident that Teacher X practices what he believes. And his teaching approach is meant to fulfil his course design by implementing teaching strategies that cater to diverse learners. Furthermore, his confidence with using a Smartboard when teaching supports his belief that Smartboards simplify his teaching and that it is easier to motivate learners when supplementing teaching with technology. Also, the fact that Teacher Y's espoused practice is aligned to his enacted practice, conforms to the conclusions by Breen (2018) and Ertmer et al. (2012), which suggest that enacted practice is informed by the espoused practice.

6.2.2 Main findings on Teacher Y

The following section presents conclusions on Teacher Y's practice after making a comparison between the teachers' espoused and enacted practice. Table 6.1 below presents a summary of the results.

Table 6.2: Teacher Y Summary of Findings

Media Forms	Espoused		Enacted	
	Evidence of Pedagogical Value	**Key**	**Evidence of Pedagogical Value**	**Key**
Productive	Knowledge construction: Articulation, Animation / Model	SU, TU	Knowledge construction: Articulation, Animation / Model	TU
Narrative	Apprehending Structure: Non-linear, Multimodality	SU, TU	Apprehending Structure: Non-linear, Multimodality	SU, TU
Interactive	Exploring: misconceptions and amend, Immediate feedback	SU, TU	Exploring: misconceptions and amend, Immediate feedback	SU, TU
Communicative	Re-description of concepts: Collaboration, Discussion	TU	Re-description of concepts: Collaboration, Discussion	TU
Adaptive	Concretizing theory and practice: Diversity, Reproduction	SU, TU	Concretizing theory and practice: Diversity, Reproduction	SU

The key for reading each teacher summary table is presented as follows:

SU: Smartboard used, TU: Tablets used, NSTU: No Tablets or Smartboard used, NDT: Non-digital technology used, NONE: No media form

Table 6.2 above presents the comparisons between Teacher Y's espoused and enacted practice. It is evident from the table that the espoused and enacted practices are consistent with minimal discrepancies. This distribution supports Ertmer et al's. (2012) claim that the pedagogical beliefs of teachers have a strong influence on actual teaching. In essence, his pedagogical belief regarding the use of Tablets and Smartboards necessitates his successful integration of these technologies in his teaching practice. Furthermore, the results also indicate that machine affordances are crucial in every aspect of teaching, and Teacher Y integrates them with non-digital technology to improve the quality of his teaching. As a result, it is logical to conclude that Tablets and Smartboards have a strong pedagogical value in terms of teaching Physical Sciences.

In the productive media, Teacher Y brings forth the argument that the pedagogical value of Smartboards and Tablets is evident in their ability to allow learners to model and enhance learning through the use of productive media such as word processors and emails. Not all learners are auditory learners, some learn through practice, some through visuals. As a result, Teacher Y's inclusion of digital task submissions suggested the value of adaptive capability of Tablets in teaching and learning of Physical Science. In essence, it becomes clear that the teacher also used diverse teaching and problem-solving techniques, by allowing learning to take place using different Tablet computer applications, and tracking how the students developed their skills and knowledge.

There is also a possibility that teacher Y has strong confidence in the affordance of Smartboards and Tablets in complementing and transforming teaching and learning. Visual properties afforded by Smartboards and Tablets rank very high in his pedagogical belief. In addition to his support for videos as an alternative when learners have no resources to conduct experiments, he also used videos to explain concepts in his enacted practice. In his class, he used multimodal text, visuals, and audio to simulate the real-life experience, which is a confirmation that these technologies enhanced his teaching and thus enhancing comprehension by learners. In principle, his teaching approach using the narrative media forms replicates his espoused teaching approach with Tablets and Smartboards.

The pedagogical value of Tablets and Smartboards in teaching and learning Physical Science is also evident in Teacher Y's espoused practice`s interactive form. There is a strong impression that the teacher values Smartboards for their ability to help him teach effectively.

In his words; “The Smartboard is everything in one, from demonstrations; research, getting extra resources to writing notes”, interaction with the Smartboard enables him to engage the students, study learners` reactions throughout the class session. In the enacted practice the teacher evocatively engaged with his learners throughout the lesson, using his laptop together with the Smartboard to supplement classroom conversation. Also, the teacher used the whiteboard to further illustrate concepts. In principle, the teacher integrated digital and non-digital resources to explicate his explanations to clear all misconceptions identified in his interaction with the learners.

Teacher Y did not explicitly point out in his espoused practice that communicative media form is the most important aspect that is needed to integrate Smartboards and Tablets in teaching and learning of Physical Science. However, in his enacted practice, communicative media form drives the learning process through collaboration between the learners and the teacher. As this collaboration takes place, peer-to-peer communication in group work, class presentations, and virtual activities augment learner's understanding of concepts as they work towards the topic goal. Therefore, enabling re-description of concepts and empowering learners with analytical, and critical thinking skills, analysis of facts to form a judgment.

Although Teacher Y indicated in his espoused practice that he used Smartboards to adapt material when explaining concepts, there is no evidence from the observed class that he adapted any material from the Smartboards to explain concepts. Instead, he projected a PowerPoint presentation on the Smartboard. However, he used the same Smartboard to add extra notes as the class progressed. In addition, he used a whiteboard to draw illustrations and write additional explanations. In the end, this proved that he integrated the Smartboard with other non-digital resources to the extent of the capability of a Smartboard. He gave additional individual and group tasks for submission that were accessible on the learning portal. Thus enabling him to apply a mixture of different teaching strategies that permit learners to choose the learning approach that works better for them.

Conclusion

Teacher Y’s espoused practice is to a greater extent aligned to the enacted practice. It is evident from his teaching approach that the use of Smartboard in teaching physical science stem from his understanding and belief in digital teaching media. Also, the fact that Teacher Y’s espoused practice is aligned to his enacted practice, conforms to the conclusions by Breen (2018) and Ertmer et al. (2012), which suggest that enacted practice is informed by the espoused practice. Another reason could be that Teacher Y’s experience and knowledge of

using Smartboards and Tablets when teaching is the source of confidence, that lead to his successful integration of these technologies in his lessons.

6.3 Integrated Summary of Findings

It is evident from this research that the relationship between the teacher's beliefs and their actual practice confirms the importance of the media forms they use. Hence, it is important to provide the integrated Summary of findings explained in this chapter as presented in table 6.3 below.

Table 6.3: Integrated Summary of findings

Media form	Data	Effective use	Not Effective use
Productive *(Tablets and Smartboards)* *Articulation Affordance: Individual and group take home tasks for submission*	Enacted	Teachers give tasks to learners so that they do in groups and individually. In essence enabling them to produce feedback using the productive capability of the word processors and emails.	The use of Tablets in this case is mostly outside the classroom.
	Espoused	Learner Use Tablets both groups and individually basis using the productive capability of the word processors and emails. Learners present their analytical skills and discuss their understanding of concepts taught.	The use of Tablets in this case is mostly outside the classroom. It is not used to create new knowledge but as an enabler of feedback production.
Narrative *(Tablets and Smartboards)* *Non-linear Affordance: Multimodality* (*Use a portfolio of affordances*)	Espoused	Engagement of multimodal Text, visuals and audio when teaching simplify subject content.	Visuals may carry different messages. Henceforth it should be implemented as a portfolio of non-liner media forms
	Enacted	Learners use Tablets to enhance interpretation of concepts and simulate real life experience thus enhancing comprehension.	Use of text and image without synchronisation
Interactive *(Tablets and Smartboards)* *Immediacy Affordance: immediacy – to accelerate achievement of curriculum goals*	Espoused	Accelerate achievement of learning goals through use of Tablets to improve access to content. Helps teachers to give, receive and use feedback effectively. Immediate feedback enables quick correction of misconception and wrong answers. Easy navigation when presenting in class	More content covered, which may lead to information overload.
	Enacted	Learners use Tablets to share content, and submit work, thus improving the speed in terms of accessing information. Learners receive feedback timely and correct errors. Also learner feedback improves classroom conversation, dictates the pace of learning and the direction for learning.	More content covered, which may lead to information overload. Teacher might not be able to address all feedback from learners.
Communicative *(Tablets and Smartboards)* *Collaboration Affordance: Group tasks and presentation*	Espoused	Teachers are able to create small and manageable groups. Learners discuss through group work and presentation via virtual applications like email and messaging Apps	Tablets are not dedicated communicative devices unless appropriate applications are added to the device. Smartboards are limited to visual one way communication
	Enacted	Smartboards and tablets used to initiate discussions in class. Empower learners with analytical, and critical thinking skills, analysis of facts to form a judgment through debate.	Tablets are not integrated as primary communication devices in classroom communication instead they are communication aide after class.
Adaptive *(Tablets and Smartboards)* Diversity Affordance: *Use of drawings and other artistic features to enhance learning*	Espoused	Adopting designs that can be transformed to suit teaching and learning needs of learners. Use of drawings and other artistic features to enhance learning	Partly integrated. Tablets and smartboards only being used as teaching aids.
	Enacted	Integration of Tablets and Smartboards with classroom conversation to help to consolidating theoretical knowledge through practice with the Tablets applications by learner and teacher.	Partly integrated. Tablets and smartboards only being used as teaching aids.

Chapter Seven

CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter gives a summary of the findings in relation to the research questions and their objectives. It also gives reference to the organisation of the report whether there was an answer to the research question or whether the objectives were achieved.

7.2 Organisation of the Research Report

The first part of the research focused on the objectives and aims of the research. The idea was to investigate the pedagogical value of using Smartboards and Tablets in teaching and learning Physical Science. In essence, the researcher needed to determine some of the factors that would assist in answering the set-out objectives and aims. This would, however, contribute to the literature that supports the research questions and the objectives. In order to understand the direction this would take an in-depth look was done to review existing works of literature that also focused on similar researches. This also assisted in shaping this research. Engaging in the existing literature, helped in developing the framework which was used. The framework was adopted from Laurillard which was modified to suit the approach to this research. Included also is the overview of the choice of the research methods which focused on how the data would be collected. This is highlighted on the target groups, area of study, limitations of the study, and the ethical issues regarding issues of doing research in a school environment. The last section dwelled on analysing the collected data. It summarised what was collected from the targeted respondents and how it helped to answer the research objectives.

7.3 Achievement of Objectives

The focus of the research was to find out if the use of Smartboards and Tablet computers can bring value to the teaching and learning of Physical Science at Further Education and Training (FET). To ensure that the research questions and the objectives were achieved, the collected

data was analysed for verification. However, the results have shown that the use of these technologies created the desire by the teacher in creating materials that helped learners to respond actively to those challenging areas of the topic taught during the data collection period. Learners were very enthusiastic when they were taught how to search for information using their Tablets. As the lessons progressed it was evident that learners enjoyed using these technologies.

7.4 Reflections and Challenges

The emergence of COVID 19 was a defining moment for the whole project as it came unannounced. As everything was closed the anxiety of whether l will be able to collect data almost created a bit of a panic. However, apart from the confusion which gripped the world and South Africa things gradually started to open up. This provided the opportunity to visit schools with the aim of quickly collecting data. During this time accessing schools was difficult since more cases began to be detected in schools. Most schools had to close including the targeted schools. As access was granted upon adhering to COVID 19 protocols, I managed to gain entry into the two schools. The focus of this study was initially targeting grade tens and elevens. The idea was not to disrupt the program of grade twelves who were sitting for their final exams. However, during this time the grade twelves were the only group allowed to return to schools. They eventually became my target group. Both the teachers and learners showed great desires for the use of the investigated gadgets and technologies. The enthusiasm by teachers was very evident knowing that the available search engines provided them with opportunities to retrieve any information they would need in their lesson delivery of Physical Science.

Despite all the glittering presence of the Smartboards and Tablets, there were a lot of challenges to be dealt with. In the initial stages, teachers were hesitant to use the technologies due to inexperience. Most parts of the lesson were done using the old system. This was a hiccup that was addressed by government technicians. Sometimes when things seemed to be flowing the Smartboard would just freeze in the middle of a lesson and in most cases, the fault would require the service of a technician who was not stationed at schools. Load shedding is one of the biggest challenges. Electricity would just be switched off in the middle of a very important lesson. This had a strong bearing on the syllabus coverage, as in the case of load shedding the lesson had to be repeated especially if it involved materials that can only be accessed on the

Smartboard. One school experienced the theft of the Smartboards itself. Most learners got robbed of their Tablets when they were going home. Some learners had the audacity of deleting important educational stuff and upload music, games, and other irrelevant material. Universally, the study also reveals that theft of these electronic devices has hampered the progress of fully integrating Smartboards and Tablets in teaching Physical Science. In addition, it is unfortunate that in South Africa technology in schools is not used properly to benefit both teachers and learners because the training of teachers and learners is not taken seriously.

7.5 Chapter Summary

In this research, the adaptive, communicative, and narrative media forms were found to be the most used and are more valuable to teaching and learning Physical Science. Although the interactive and the productive media forms were used less often than the adaptive, communicative, and narrative media forms, they were found to equally impact teaching and learning of physical science positively. The research also found out that the productive media have a propensity to impact teaching and learning more because of its predisposition to offer more affordances, which help to transform learners with technical, cognitive skills, and analytical skills needed for knowledge construction and presentation.

Since learning takes place through re-description of concepts to ensure that learners understand, this study also found out that the communicative media form empowers learners with analytical, and critical thinking skills, analysis of facts to form a judgment. Also, communication enables learners to communicate their misconception, at the teachers clear their misconceptions. More so, it is evident from this research that collaboration between learners and between learners and teachers is easily promoted through the use of Tablets through applications that allow online information creation and sharing. This can be interpreted as extended classes or online classroom conversations. Thus integrating the adaptive media, the interactive media, and the communicative media forms. The interpretation of the interactive media led to the conclusion that it quickens the learning process and drives learning towards achieving curriculum and lesson goals.

The two teachers engaged in this research provide that the material design has a strong influence on the integration of different media forms in the classroom. Also, the research concludes that learning design the learning setting and how learners converse with the teacher. In both their belief and practice, the research found out that engaging different media is a clear

indication of the practical ways of initiating collaboration through individual, class, and or group work. This evidence is in unison with the analytical framework developed for this research adopted from Laurillard (2002). Although the conversational framework designed by Laurillard (2002) applied more to physical offline classes, this research found out that, whichever way tablets and Smartboards can bring the same pedagogical value, be it offline, online, or combined. Finally, this research concludes that the use of Smartboards and Tablet computers bring value to the teaching and learning of Physical Science at Further Education and Training Level.

It would be thought-provoking to evaluate a Tablet as a host of a stand-alone course in form of an application. The interactive capabilities of Smartboards could be enhanced by developing interactive course lessons as an independent application. For example, developing a Grade 12 Physical Science application using instructive and pedagogical approaches, where students learn the course by merely interacting with the application of the device. That way, learners could then gain full control of their learning experience. This form of pedagogical integration could afford learners the liberty to freely pursue knowledge creation and acquisition relative to curiosity and self-styled individual learning approaches. In essence, the interaction with tablets in classroom teaching may be reinforced with interactive home homework and reflections.

7.6 Contributions of this Study

This study will contribute to the body of knowledge focusing on the use of Smartboards and Tablets to enhance understanding in the teaching and learning of the subject Physical Science. Future research can take the results of this research as a guide to pursue other avenues in finding if there is any pedagogical value in other technologies in the teaching and learning of Physical Science and other subjects.

7.7 Limitations

This study focused on two schools in the same district. As a result, the conclusions from this research should be treated with caution especially when making generalisation about the pedagogical value of Smartboards and Tablets in the context of South Africa as a whole. The technological infrastructure of schools across South Africa and the skills of teachers in terms

of the use of Smartboards and Tablets in teaching and learning physical science may not be the same.

7.8 Recommendations

This research focused mainly on the pedagogical value of Smartboards and Tablets in teaching and learning Physical Science. It may be interesting to look into the factors or variables that influence the successful integration of Smartboards and Tablets in a Physical Science classroom. In addition, this research focused on the espoused and enacted practice and the role of the teacher in integrating these technologies in teaching and learning, it also found out that these technologies can influence online learning. Future studies could look into the impact of using Tablets in online distant learning for Physical Science at Further Education and Training Level. As this study only focused on two schools and one grade more comparative research needs to be done to further ascertain if Smartboards and Tablets can bring any value in the teaching and learning of Physical Science in different levels of secondary education.

7.9 Research Conclusion

This research has shown that learning takes place where there are enablers, the learning setting, and the policy. This all emanates from the beliefs of the constructivists' theories, which strive to set direction on how learning takes place, with the notion that that says "learners create knowledge rather than just passively take in information" (Fox and Schirrmacher, 2011, p. 79). In principle, knowledge creation is done with the help of learning tools be it digital or non-digital. As a result, this study needed to look into technologies that bring in affordances that could enable the creation and sharing of knowledge. However, the researcher chose to adopt Laurillard's (2002) Conversational Framework. This framework helped to structure this research to investigate the pedagogical value of Smartboards and Tablets, in teaching and learning Physical Science, focussing on the five media forms that bring value to the learning process.

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Appendix 1: Letter to the principal

APPENDIX 1

The letter to the principal

Dear Principal

My name is Taurayi Chigamba. I am a Masters student in the school of Education at the University of Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project and the topic of my study is, **TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS** under the supervision of Dr. Nokulunga. S. Ndlovu.

The aim of this research is to understand how the use of Tablets and Smartboards adds to the pedagogical value in teaching and learning of Grade 10 Physical Science. As a result, I will make use of observations as a method of data collection in order to gain a situational experience of how these technologies are used in practice to enhance teaching and learning. The teacher interview will also be conducted in order to understand what informs the teachers' use of the two technologies in their classrooms.

As part of this project, I am requesting permission for the participation of your school in this project. The reason I have chosen your school is because there are teachers and learners who use Smartboards and tablets for teaching and learning. The research will focus on a teacher who is teaching a Grade 10 Physical Science subjects at Grade 10. The teachers will be invited to take part in an interview, and I will observe their lessons while teaching with Smartboards and their learners using tablets. With your permission, I would also like to videotape the use of Smartboards and Tablets in the classroom. In order to capture all data related to this study, audio recording for interviews and video recording will be done in order to ensure detail in the descriptions of the use of Smartboards and tablets is captured for analysis purposes. While this study will focus on the teacher teaching during lesson presentation, the teacher's and learner's faces will be blurred in the presentation of data and focus will be on what they do with their hands as t to learn in they interact with the tools during the lesson so that they are not identifiable. The interview with the teacher will not affect the daily routine of teacher's duties at the school because they will be conducted before the lesson observation whenever the teacher is available, and it will not last more than 30 minutes per session. One lesson will be observed in this study. The lesson to be observed will be taught as per school's teaching load and timetable. During the lesson observation, I will assume the role of a passive participant while the teacher teaches with Smartboards and learners use Tablets in their learning.

At this stage, permission from the Gauteng Department of Education (GDE) has been sort through the submission of an ethics application and I am awaiting approval. I intend carrying out the research as soon as permission is granted by the GDE and yourself as the principal. The teachers participating in this study will be issued with the information sheet that I will brief them on and give them to read. Secondly, I will ask them to complete the consent forms which they will sign. In the case of learners, I will seek permission from the parents first. Learners will be given information sheets and consent forms to give to their parents and request that they sign to consent their child's participation in this study. Learners of parents who would not have signed the forms will be identified and will be excluded from all data presentations.

There are no foreseeable risks in participating in this study and participants will not be advantaged or disadvantaged in any way. Your school and the participant's confidentiality will

Appendix 2: Letter to the teacher

APPENDIX 2

Letter to the teacher

Dear Sir/ Madam

My name is Taurayi Chigamba and I am a Masters student in the School of Education at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating on the **TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS** under the supervision of Dr. Nokulunga. S. Ndlovu. The aim of this research project is to find out if their use has any pedagogical value in teaching and learning of Physical Science.

As part of this project, I would like to invite you to take part in an interview and seek your permission to also observe your lessons while you teach. This is activity involve a single interview and will take around 15 minutes. Lesson observation will take around 30 minutes. With your permission, I would also like to record the interview and the lesson observations using a cellphone. Because of the complexity of data collection of this practice, the use of videos is used to understand the value of the use of these devices and come up with a thick description. Please be assured that during video recording your face and the face of the learners will be blurred.

There will be no personal costs to you if you participate in this project. Also, you will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. There are no foreseeable risks in participating in this study and participants will not be advantaged or disadvantaged in any way. Your school and the participant's confidentiality will be preserved as data collected will not be shared with anyone. Pseudo names for the participants and your school will be used in the presentation of this report. You may withdraw at any time or not answer any question if you do not want to. . I will make this report available to you for scrutiny before it is published. In the event that you wish to have a copy, a copy on its publication will be presented to you. All data will be destroyed between 3-5years after completion of the project.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0)11 717 1408, email hrec-medical.researchoffice@wits.ac.za. Please let me know if you require any further information. I look forward to your response as soon as is convenient.

I enclose two copies of this letter. Please keep one for your files.

Yours sincerely
Taurayi Chigamba

Researcher
Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor
Dr. Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 3: Letter to the learner

APPENDIX 3

Letter to the learner

Dear learner

My name is Taurayi Chigamba and I am a Masters student in the School of Education at the University of Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating on the **TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS** under the supervision of Dr. Nokulunga.S. Ndlovu. The aim of this research project is to find out if their use has any pedagogical value.

This letter is to seek your consent to allow me to observe your Physical Science lesson. I will be observing on how you use your tablets together with the teacher's instruction on the smartboard. During observations I will be a passive learner sitting at the back learning about the use of Smartboards and Tablets. During the observation, video recordings and audiotaping will be done only be used for data collection so that I will be able to further understand how the class went. Please be informed that the recordings will not be published anywhere after concluding the research.

I will not be using your name but I will make some mock names one to identify you. Your faces will not be visible in the video recordings. A cell phone video recording will be used in instances where data cannot be quickly captured. The focus will be on the tablets and your hands as you use them, otherwise your faces will be blurred also. All information about you will be kept confidential in all my writing about the study. Also all collected information will be kept safely and destroyed between 3-5years after I have completed the project.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrec-medical.researchoffice@wits.ac.za

I look forward to working with you.

Please feel free to contact me on the numbers below if you have any questions.

Yours sincerely

Taurayi Chigamba

Researcher

Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor

Dr Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 4: Letter to the parent

APPENDIX 4

Letter to the parent

Dear parent

My name is Taurayi Chigamba. I am a Masters student in the school of Education at the University of Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating on the **TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS** under the supervision of Dr. Nokulunga.S. Ndlovu. The aim of this research project is to find out if their use has any pedagogical value.

As part of this project, I am seeking permission for the participation of your child in this research project. I will be doing lesson observations, video and audiotaping during their class lessons on the use of Smartboards and Tablets. The focus will be on the tablets and the learners' hands as they use them, otherwise their faces will be blurred also. No names and faces will be revealed. The reason I have chosen your child is because he/she is doing the subject that I am targeting in this research, Physical Science and its taught using Smartboards and Tablets.

Your child will not be advantaged or disadvantaged in any way. S/he will be reassured that s/he can withdraw his/her permission from participating in this project without penalty. There are no foreseeable risks in participating and your child will not be paid for this study.

Your child's name and identity will be kept confidential at all times and in all academic writing about the study. His/her individual privacy will be maintained in all published and written data resulting from the study.

All research data will be destroyed between 3-5years after completion of the project.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrec-medical.researchoffice@wits.ac.za

Please let me know if you require any further information.

Thank you very much for your support.

Yours sincerely
Taurayi Chigamba

Researcher
Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor
Dr. Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 5: Principal consent letter

Principal consent letter

TITLE: TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS.

Dear Mr. Taurayi Chigamba

I, ... (Principal) give permission to Mr. Taurayi Chigamba to conduct his research project in this school in the topic. I understand that the research involves the participation of my teachers and learners in the school. I agree to the following:

(Please circle the relevant options below).

I agree that the participation of my teachers and learners will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview and lesson observations may be video or audio recorded	YES	NO
I agree that the information collected may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

..... (signature)
..... (name of participant)
..... (date)

Researcher

Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor

Dr Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 6: Teacher consent form

Teacher consent form

TITLE: TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS.

Dear Taurayi Chigamba

I, _____ (teacher), agree to participate in the research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview and lesson observation may be video and audio recorded	YES	NO
I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

..... (signature)
..... (name of participant)
..... (date)

Researcher

Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor

Dr Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 7: Learner consent form

Learners assent form

TITLE: TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS.

Dear Taurayi Chigamba

I, ..., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

..... (signature)
..... (name of participant)
..... (date)

Researcher

Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor

Dr Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 8: Parent consent form

PARENT CONSENT FORM

Please fill in and return the reply slip below indicating your willingness to allow your child to participate in this research project.

TITLE: TEACHING AND LEARNING OF HIGH SCHOOL PHYSICAL SCIENCE WITH SMARTBOARDS AND TABLETS.

Dear Taurayi Chigamba

I _____, the parent of _____

	Circle one YES/NO
Permission to allow your child sit in class as I observe his/her teacher teach	
I agree that my child may be observed in class.	YES/NO
Permission to be audiotaped	
I agree that my child may be audiotaped during observations.	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be videotaped	
I agree my child may be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My child's name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- He/she does not have to answer every question and can withdraw from the study at any time.
- he/she can ask not to be audiotaped, photographed and/or videotape
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Signature_____ Date _____

Researcher
Name: Taurayi Chigamba, 735160@students.wits.ac.za, +27 74 498 3634

Supervisor
Dr Nokulunga. S. Ndlovu, Nokulunga.ndlovu@wits.ac.za, +27 82 220 04487

Appendix 9: GDE consent letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	01 June 2020
Validity of Research Approval:	04 February 2020 – 30 September 2020 2019/469
Name of Researcher:	Chigamba T
Address of Researcher:	8 Umngeni Court
	41 Rietfontein Road/Primrose
	Germiston
Telephone Number:	011 616 5220/0744983634
Email address:	tauchigamba@yahoo.com
Research Topic:	Teaching and learning of High School Physical Science smartboards and tablets
Type of qualification	Master's in Education
Number and type of schools:	2 Secondary School
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 to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

01/06/2020

The following conditions apply to GDE research. The researcher 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:

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix 10: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Chigamba

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H20/02/07**
PROJECT TITLE	Teaching and learning of high school Physical Science with smartboards and tablets
INVESTIGATOR(S)	Mr T Chigamba
SCHOOL/DEPARTMENT	Education/
DATE CONSIDERED	14 February 2020
DECISION OF THE COMMITTEE	Approved Permission letters required before data collection can commence Risk Level: Minimal
EXPIRY DATE	27 May 2023

DATE 28 May 2020 **CHAIRPERSON** _____
(Professor J Knight)

cc: Supervisor : Professor N Ndlovu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ _____/_____/_____
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 11: Teacher interview guide questions

TEACHER INTERVIEW QUESTIONS

1. How long have you been teaching?
2. Is Physical Science the only subject you have been teaching?
3. What challenges have you faced in teaching this subject?
4. If there were challenges how did you overcome them?
5. Are there any responsibilities associated specifically with your subject? Give details.
6. How did you plan your lessons before smartboards and tablets were introduced to your school?
7. What type of technology were you using before smartboards were introduced? Did it help in learner attainment?
8. What was your feeling when smartboards were introduced in your school?
9. Do you think the introduction of smartboards and tablets brought more advantages than disadvantages or vice versa? Elaborate.
10. Did you face any challenges in this transition? Please give details
11. What was the perception for both teachers and learners on their reception of these gadgets?
12. Was there some form of training given to you before you use the smartboards? Please give details.
13. Did the learners also receive any form of training?
14. What does successful technology integration mean to you?
15. Do you perceive technology to be the answer to the challenges you faced in physical science lesson delivery? Explain
16. Technology does not always work the way it should be; how do you handle disruptions?
17. Is it easy to adjust and complete the planned lesson without the use of technology?
18. Has the behaviour of learners towards these technological gadgets changed for the better or worse? Specify.
19. Is there an improvement of pass rate ever since these gadgets were introduced?
20. Can we credit the improvement of pass rate to the introduction of smartboards and tablets to learners?

Appendix 12: Interview teacher "X"

Response to the interview questions for Teacher

Question 1

Interviewer:

How long have you been teaching?

Teacher X:

I have been teaching since 1993 (27 years to be precise)

Question 2

Interviewer:

Is Physical Science the only subject you have been teaching?

Teacher X:

No, apart from physical science, I am also teaching Mathematics, Mathematical literacy and Natural science.

Question 3

Interviewer:

What challenges have you faced in teaching this subject?

Teacher X:

When I started my teaching career, my first school was in Mpumalanga Province, I was teaching three grade 12 classes of about 50 learners each, we had shortage of textbooks and no laboratory, we had a mobile lab which was not fully equipped and was used by six science teachers sharing it between classes.

Question 4

Interviewer:

If there were challenges how did you overcome them?

Teacher X:

For our practical lessons we collaborated with neighbouring schools and university of Pretoria to assist us with equipment and doing one or two experiments, at times we arranged for our learners to visit the university just to see how a LABORATORY looks like, the costs involved to take learners to University of Pretoria were huge, travelling long distance just for two experiments.by the way these were learners whose parents were unemployed and destitute.

Question 5

Interviewer:

Are there any responsibilities associated specifically with your subject? Give details.

Teacher X:

Yes, I am the Head of the science and technology department and I am responsible for Physical science, Natural science, Technology and Life science. I manage and lead the department with the help of my team.

Question 6

Interviewer:

How did you plan your lessons before Smartboards and Tablets were introduced to your school?

Teacher X:

I planned my lessons using a textbook, charts, paper and pen. Planning was tedious because one had to scribble first before a good lesson could be produced. Later in years' lesson templates were provided and some textbooks had sample of lessons we could adapt for our classroom.

Question 7

Interviewer:

What type of technology were you using before Smartboards were introduced? Did it help in learner attainment?

Teacher X:

I used video player, overhead projector and later laptop and projector were introduced. Teaching became much better and INTERESTING FOR BOTH TEACHERS AND LEARNERS.

Question 8

Interviewer:

What was your feeling when smartboards were introduced in your school?

Teacher X:

It was very scary and exciting at the same time, just to see a giant screen in front of you with lots of touch buttons was intimidating. Remember when smartboards were introduced teachers were not given training we had to train and use them as we go along, it was on job training so to speak. Your lesson could just vanish before your eyes without the understanding of what could have happen, and learners would be watching and laughing as one fumbles trying to get the vanished page back. It was hilarious for the learners but later they assisted us because they were better in using technology.

Question 9

Interviewer:

Do you think the introduction of Smartboards and Tablets brought more advantages than disadvantages or vice versa? Elaborate.

Teacher X:

As I got used to the features of the Smartboard and the skills improved, I found the use of the Smartboard advantageous because I could access textbooks, use past question papers, play video lessons, write and save notes to be used with the next class or refer back to the same notes to emphasis some points later. Where materials for an experiment could not be purchased a video of an experiment could be shown on the screen of the Smartboard. I also found that the use of the smartboard saved time, learners became more interested in the lesson especially if they were given an opportunity to interact with the board, dust from the chalk was history, did not suffer from flu as often as I used to and my jackets were free from chalk dust.

Question 10

Interviewer:

Did you face any challenges in this transition? Please give details

Teacher X:

Yes, I indicated that we were not trained to use the smartboard, navigating through all the icons was a challenge, just to erase a text or retrieving last save work was not easy.

Question 11

Interviewer:

What was the perception for both teachers and learners on their reception of these gadgets?

Teacher X:

To be honest at first I was sceptical, I didn't use the Smartboard for a good full week, I was afraid to make mistakes but for the young teachers who have just joined the system, was fun and they were so positive.

Question 12

Interviewer:

Was there some form of training given to you before you use the smartboards? Please give details.

Teacher X:

Yes, later technicians were deployed to schools to give us crush course twice a week, this training became useful because my confidence improved but at times they could not solve all our challenges. THEIR SERVICES WERE LATER TERMINATED AND WE CONTINUED TO STRUGGLE.

Question 13

Interviewer:

Did the learners also receive any form of training?

Teacher X:

No, learners were not given training as a result they used the tablets for downloading movies, music and playing games. Teachers were not able to send work to learners because of lack of skills.

Question 14

Interviewer:

What does successful technology integration mean to you?

Teacher X:

Successful technology integration to me means to use technology resources such as laptop, cell phone, computers to design a meaningful, exciting lesson and for learners to use this resources to create music, movies, communicate their thoughts and link with the global community. A successful integration of technology with the classroom can be a great way of strengthening the engagement and participation of learners. Being able to send learners updates through WhatsApp and email. It is unfortunate that in South Africa technology in schools is not used properly to benefit both teachers and learners because training of teachers and learners is not taken seriously.

Question 15

Interviewer:

Do you perceive technology to be the answer to the challenges you faced in Physical Science lesson delivery? Explain

Teacher X:

Yes, since schools are not equipped with functional laboratories, technology can empower teacher to use technology successfully in preparing lessons. Unfortunately, the use of Smartboard would be interrupted by load shedding and we would be disconnected for days.

Question 16

Interviewer:

Technology does not always work the way it should be; how do you handle disruptions?

Teacher X:

It is true, in our schools and communities we often experience load shedding as a result we become frustrated and resort to old ways of using chalk boards, paper and pen. One of the main challenges is burglary and vandalism of resources which happens almost every time when schools are in recess. These acts of sabotage derailed us,

Question 17

Interviewer:

Is it easy to adjust and complete the planned lesson without the use of technology?

Teacher X:

Well for old teachers like me it is easy but for young teacher it's frustrating.

Question 18

Interviewer:

Has the behaviour of learners towards these technological gadgets changed for the better or worse? Specify.

Teacher X:

For some learners it has transformed their behaviour for the better because one can see their enthusiasm in using the technology but for some their behaviour has not changed, they see technology as resources for entertainment.

Question 19

Interviewer:

Is there an improvement of pass rate ever since these gadgets were introduced?

Teacher X:

No, the performance in Physical Science can be attributed to more hours of hard work rather than the use of technology because some learners do not have smart phones and we cannot interact with them through WhatsApp or online learning and Tablets were discontinued as a results there was to meaningful sharing of information that can lead to improvement of results.

Question 20

Interviewer:

Can we credit the improvement of pass rate to the introduction of Smartboards and Tablets to learners?

Teacher X:

No, Smartboards help but not to the extent of improving the results since a lot of training is still needed to empower us as teachers.

Appendix 13: Interview teacher "Y"

Teacher Interview Questions and Answers.

Question 1

Interviewer:

How long have you been teaching?

Teacher Y:

I've been teaching for 15 years now.

Question 2

Interviewer:

Is Physical Science the only subject you have been teaching?

Teacher Y:

Yes, I am teaching Physical Science only ever since.

Question 3

Interviewer:

What challenges have you faced in teaching this subject?

Teacher Y:

The main challenge I've been facing in the 3 schools I've been teaching; inclusive my current school is the nonexistence of a proper science laboratory. The lab is not well equipped, hence compromising the whole purpose of hands on learning and teaching.

Question 4

Interviewer:

If there were challenges how did you overcome them?

Teacher Y:

We ended up using a make shift laboratory in the form of an ordinary classroom converted into a lab and trying to source for assistance from the corporate world for chemicals and equipment. Sometimes we get assistance from well- wishers.

Question 5

Interviewer:

Are there any responsibilities associated specifically with your subject? Give details.

Teacher Y:

I am the Sciences head of Department, heading Life Sciences; Physical science and Computer Applications Technology.

Question 6

Interviewer:

How did you plan your lessons before smartboards and tablets were introduced to your school?

Teacher Y:

We use to receive Lesson plan templates from the Department of Education that we complete every week for the lessons.

Question 7

Interviewer:

What type of technology were you using before smartboards were introduced? Did it help in learner attainment?

Teacher Y:

We've got a fully functional ICT Department in the school that provides learning and teaching media in the form of DVD players, overhead projectors, laptops cassette radios etc. Both learners and teachers benefitted from this.

Question 8

Interviewer:

What was your feeling when smartboards were introduced in your school?

Teacher Y:

It was a great feeling, since during our training one could feel that the old days are gone, of using the textbooks, carrying chalk and duster to class, etc.

Question 9

Interviewer:

Do you think the introduction of smartboards and tablets brought more advantages than disadvantages or vice versa? Elaborate.

Teacher Y:

The introduction of these two brought more advantages than disadvantages for my subject, since learning is now centralised, from learning and teaching material to lessons on videos and researching since our smartboards and tablets/smartphones are internet networked.

Question 10

Interviewer:

Did you face any challenges in this transition? Please give details

Teacher Y:

In the early days it was a challenge, because operating the smartboard with the little training we received was not enough, hence wasting lesson time in the process of failing to access stuff and operating the smartboard to its fullest capacity.

Question 11

Interviewer:

What was the perception for both teachers and learners on their reception of these gadgets?

Teacher Y:

As for the learners; having a tablet for learning was a new thing, so accessing information was a problem for some and worse using the tablet for other things like playing games and music during the lesson or outside the lesson, thereby wasting time for doing home works and studies. As for me using the smartboard was a positive thing and I was very much looking forward to it with the technical knowledge that I have from University.

Question 12

Interviewer:

Was there some form of training given to you before you use the Smartboards? Please give details.

Teacher Y:

Yes, we had some time for training for the Smartboards use and Tablets, through district ICT department. Trainings were done in selected schools around our cluster and at our schools through GDE Interns.

Question 13

Interviewer:

Did the learners also receive any form of training?

Teacher Y:

As for learner tablet training; teachers and interns were tasked to carry out trainings in schools.

Question 14

Interviewer:

What does successful technology integration mean to you?

Teacher Y:

Successful technology integration for me; means being able to use technology to my advantage for making my teaching hassle free and for my learners' to understand my lessons better as compared to not having this type of technology. For example, Learners can play science games like 3d brain and Science Journal by Google. There are more games that help learners to experiment on their own comparing their results.

Question 15

Interviewer:

Do you perceive technology to be the answer to the challenges you faced in physical science lesson delivery? Explain

Teacher Y:

Yes, for example my research is much easier; lesson planning is also easier and one does not run out of ideas and resources since our smartboards and Tablets are connected to the internet. We can't do an experiment because of lack of equipment and chemicals, we just download lesson videos, and watch the experiment on the Smartboard and learners can also download it into their tablets and smartphones and watch it later on. I have been using this method for some time now and it makes teaching simple.

Question 16

Interviewer:

Technology does not always work the way it should be; how do you handle disruptions?

Teacher Y:

It is very true that technology does not always work the way one expects; we have got a fair share of our own problems; for example, load shading is becoming a problem at my school; hence sometimes compromising the use of the smartboards and tablets. So when load shading strikes, one is forced to go back to the old way of learning through the use of textbooks; chalk and dust. Learner sometimes use tablets for playing instead of learning. As teachers we must be able to see when learners use technology on school work and other things. The information they share using school devices. For example, media download statistics, the number of times learners go on the portal to access resources and the number of times learners read announcements and respond on discussion forums.

Question 17

Interviewer:

Is it easy to adjust and complete the planned lesson without the use of technology?

Teacher Y:

Given the way I'm now used to technology; it is becoming a problem to finish up my lesson without the use of it. For example, the Smartboard is everything in one, from demonstrations; research, getting extra resources to writing notes on it.

Question 18

Interviewer:

Has the behaviour of learners towards these technological gadgets changed for the better or worse? Specify.

Teacher Y:

During the early years it was a problem for the leaners; time was lost playing games, watching movies; playing music; on the tablets, instead of studying, but now their mind set has shifted and changed for the better.

Question 19

Interviewer:

Is there an improvement of pass rate ever since these gadgets were introduced?

Teacher Y:

Yes, there is a stable improvement of the pass rate since we started this technology, because learners are using free internet, they can now download past exam papers and memos, for the good of studying and they can also research on anything.

Question 20

Interviewer:

Can we credit the improvement of pass rate to the introduction of smartboards and tablets to learners?

Teacher Y:

Yes; we can partly give credit to technology for a significant role to the improvement of the pass rate, though not 100%.

Appendix 14: Observations transcript

1. TEACHER X CLASS OBSERVATION [45MIN]

- *Teacher comes in and greet the learners*
- *The teacher recapitulates on concepts previously covered and linking it to the day's topic.*

The Teacher begins the class with a recap on the main topics covered in the previous class and how these topics connect to the current class.

So remember from previous class equilibrium can only be achieved if these we have an inverse relationship.

The class responded "Yes Sir"

- *Everything to do with the recap from the previous class is done without using the Smartboard.*

Some learners use tablets to recap as the teacher was talking

- *The teacher introduces the topic "Lechatelier's Principle." Then he opens up the Smartboard.*

Lesson Outcomes – *board to present (A)*

Today we are talking about equilibrium in a closed system. Okay. (Topic displayed)

A closed system can have two dimensions, (temperature / pressure) – (notes)

So our focus will be on the equilibrium between pressure and volume

Also we want to know, when we increase the pressure, what will happen to the system "molecules".

We also want to know what will happen when we decrease the pressure

What is our equilibrium position? *Notes on board (A)*

It says any factor that affect either the forward or the reverse reaction relative to "R" can potentially affect the new equilibrium position

What will happen? *Notes on board (A)*

So if we increase the pressure on a system its volume will decrease as illustrated by the image (*narrative*) at the bottom here so notice as we're increasing the pressure on this lid we end up decreasing the volume of the container.

Now when we're making changes in volume or pressure we need to examine the molecules of gas on each side of an equation so realized that volume will affect pressure or we can directly affect pressure.

A student asked a question. "What happens to the molecule when pressure is increased?" the image

The Teacher responds: - *image – extend his explanation for clarity*

In this case when we decrease the pressure it means we are increasing the volume

So inverse, when we increase the pressure the effect is opposite to that what happens to the volume of the content in the system.

The opposite is that we are decreasing the volume

It means the space becomes small where the molecules are, but if the volume increase it means the pressure is less, the molecules spread over a large space

Does it make sense?

All learners responded at once “Yes sir”

The teacher continues with the class – *(A) (display -notes)*

But that will only affect the gases in a reaction.

For me personally it's easier to think in terms of volume because it's so much more visual and easier for me to picture what's happening.

Realise that if we increase the volume of a container a reaction will have more space to be able to take up or have more molecules present.

And so if we increase the volume of a container, we will see that our reaction is going to shift to the side of the reaction that has more molecules of gas.

The teacher continued with the class.

- *Teacher explains the principle focusing the work presented on the Smartboard*
- *The teacher brings in images to further deepen his explanation.*
- *Teacher randomly ask questions to attract the learner’s attention.*
- *As the teacher manipulates images in trying to further explain the concept, high level of concentration could be seen from learners wondering what could come next. A clear indication that learners symbolized visual learner.*

After some time of proceeding with the class, the teacher informed the class that they will be watching a video. And he described how the video will be structured.

> “*The video description of today we'll be describing how changes in volume and pressure can be predicted to determine the direction of shift in equilibrium. The shift of equilibrium affects the arrangement of properties or molecules*”.

- *As the teacher brings a video, there was great evidence on how the teacher had captured the learner’s attention.*

This reaction from learners suggests that learners feel motivated to concentrate when the teacher uses a portfolio of different teaching methods and media.

- *He gave them time to watch the 6 min video.(4) (Adaptive media)- summary*
- *He later asked them if the understood the video and the content altogether and poses to allow them to express areas of concern.*
- *He continued to ask random questions who responded positively to the teacher’s satisfaction.*
- *He concludes his lesson by a summary of notes displayed on the screen of the Smartboard saved on the memory stick.*
- *He assured the learners that the whole lesson presentation as he concludes his lesson that the lesson will be uploaded to their tablets.*
- *Homework will be loaded together with the lesson presentation.*

Because of COVID 19 the teacher in this lesson is confined to the front of the classroom and uses the lecture method. Most of the time 80%, the teacher is talking and there is no

interaction. The conversation/ interaction was missing at the discursive phase and that would have helped identify misconceptions earlier…it seems the technology did not add value

2. TEACHER Y CLASS OBSERVATION

1. *Teacher also comes in and greeted the learners.*
   Today we will open this class with a video. In this video we're going to focus on the electrolysis of water. So pay attention to the process. At the end we will answer the take home questions that I uploaded on the drive (portal) last week. Later on we will watch another video experiment conducted by grade 12 students of 2019. In this video we will comment whether they did it correct or wrong.
2. *Teacher introduces the main topic Electrolysis of cell but stresses that the focus is on the section Electrochemical cells.*
3. *The teacher explains in brief topic before engaging with the Smartboard.*
4. *Teacher opens up the Smartboard and locates his slides presentations.*
5. *The teacher explains the concept of electrochemical using the slide*
6. *Teacher explains using images on the slides*
   So what exactly is electrolysis?

   It's the process by which we use electricity to break down a compound into its component molecules.
   An example of water we can use electricity to break down this compound into hydrogen gas and oxygen gas.

   We know that water already have oxygen and hydrogen.

   So the water in the beaker can undergo what is called electroplating. We have learnt this year if you still remember

   The class responded all at once "Last year Prelim"

   Let's have a quick run on the diagram. As you can see, we have a beaker, water and cathodes.

   A quick and simple way is to take a beaker fill it with water or our electrolyte. Then we need to use two electrodes one of them is going to be the anode and one will be the cathode.

   Suppose if we want to get the best result, we have an option to use two carbon-based graphite electrodes. The negative electrode and the one on the right is the positive electrode.

   The next thing is to connect a battery to it so the long side is the positive terminal of the battery and a short side is the negative terminal of the battery.

   The student interrupts with a question, to get further clarity

   Student question: I just want to ask sir be for I am left behind. From this diagram, which one is the cathode and which one is the anode. Is it the same for all explanations?

Pointing at the diagram The Teacher responded: This one on the right is the negative electrode cathode and that one on the left is the positive electrode. The electrode at which oxidation occurs is called the anode.

Student question: So is the positive electrode an anode.

Teacher responded: In an electrolyte cell yes, the anode is taken to be positive while the cathode is now negative.

However, in a galvanic (voltaic) cell, the anode is considered negative and the cathode is considered positive. This seems reasonable as the anode is the source of electrons and cathode is where the electrons flow.

That is why I say, let's not define the anode and the positive and cathode as the negative electrode. Rather let's define cathode and anode in terms of oxidation and reduction.

In an electrolytic cell, oxidation reaction takes place at the anode and reduction reaction takes place at the cathode.

This is opposite with galvanic (voltaic) cell

Now to remove ions in water we use the process called Electroplating.

This is a plating process in which metal irons in a solution are moved by an electric field to coat an electrode.

This whole process involved oxidation and reduction. In this case we use electric current together with the electrode to get it positively charged.

As soon as we connect the battery electrons will flow towards the positive terminal of the battery and away from the negative terminal of the battery.

Now an electrochemical cell electrons flow from the anode to the cathode which means that the electrode on the left represents the anode and the electrode on the Left represents the cathode.

When using electrolyte, oxidation always occurs at the anode and reduction always occurs at the cathode.

The teacher went on with the class until end of the planned session.

7. *The teacher throws in questions here and there to draw the attention of learners.*
8. *The teacher clicks on the video link to give a deeper explanation.*
   Now let's look at the video demonstration then we will talk about how we can actually do this.
9. *He allows the learners to watch the video.*
10. *During this time the level of concentration is evident from the learners' silence and wanting to hear the explanations.*
11. *As the 5min clip video ends, teacher further emphasizes and ask some random questions*

The Teacher asked the learner to draw diagram.

Draw a well labelled diagram and also explain how you can electroplate nickel plate on spoon.

The learners drew the diagram on their computers while the teacher moved around watching.

12. *Most of the learners drew nice diagrams, an indication of that they were concentrating, and they understood the process.*

13. *As the teacher concludes the lesson he reminded the learners that the slides would be uploaded to the learners' Tablets.*

He asked the learners to record themselves doing practice.
Group yourselves in groups of 5, then record a video of yourself setting up electroplating nickel on a spoon. You can use any material of your choice in place of nickel. Share the video with your group members.