Educators' integration of ICT's in teaching Mechanics in Grade 10 Physical Sciences in three Approved South African High Schools.

Fumai Martin Mudindo

(Protocol Number: 2015ECE022M)

A Research Project (Thesis) in partial fulfilment of the requirements for the Degree of Master of Science (Science Education)

Supervisor

Dr. MEGAN DOIDGE

Marang Centre for Mathematics and Science Education

University of the Witwatersrand, South Africa

Johannesburg, 31 May 2016

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Declaration

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Signature :

Abstract

This research project reports on the findings of an investigation into ICT (Information and Communication Technology) integration in the teaching of Physical Sciences using the topic of Mechanics as an example. The focus of the research was the effective use of ICT in the teaching and implementation of the curriculum CAPS in the context of teaching the topic of Mechanics. Secondly, to examine the contextual variables those affect the pedagogical integration of ICT in three approved South African high schools.

Six teachers from three GDE (a province of influence in South Africa) approved high schools participated voluntarily in this research project. The topic of Mechanics was chosen for this research because learner performance in this topic in the Grade 12 examination has been found to be particularly poor, according to the report of National Senior Certificate Examinations (DBE, 2012). Poor performance in Mechanics might be due to the fact that the concept of energy is highly abstract and probably not well presented by educators starting as far as grade 10 when it commences in CAPS.

The research methodology used in this research project was Mixed Methods and a case study as a strategy. A Mixed Methods research design is a procedure for collecting, analysing and integrating both qualitative and quantitative research and methods in a single study to understand a research problem (Creswell, 2012). A case study was motivated by its close connection to the Mixed Methods research design that search for and report complex dynamic and unfolding interactions of events and other factors in unique processes (Cohen, Manion and Morrison, 2011).

ICT integration in the Physical Science classroom in teaching complex topic like Mechanics brings about a unique classroom process obviously different from a traditional one.

Hence Technological Pedagogical Content Knowledge (TPACK) was used as a theoretical construct that assists in explaining the new science classroom and the teaching dynamics that unfolds in there. Park et al. (2008) studied the effect of ICT in science education on the achievement of Korean middle school students and found a significant difference in the achievement level of the control and experimental class. Livingstone (2012) reported that in the UK a different technology, interactive whiteboards is associated with an improvement in pupils' performance in national tests in English (particularly for low-achieving pupils and for writing), mathematics and science.

TPACK instruments or tools used in this project were the initial questionnaire, an observation schedule, a main questionnaire and a follow-up questionnaire. The responses obtained from these tools were all collected as data and was prepared by coding individual scripts, duplicating and digitizing for ease of safe storage and scoring. The generated scores were then analysed, using the Rasch statistical model.

The functionality of the Rasch statistical model was to quantitatively establish the extent of pedagogical and technological use of ICTs in selected educators and the rest of the data was to qualitatively examine the contextual variables that affect the pedagogical integration of ICT.

The Rasch statistical model was used to determine the extent of effective use of ICTs for pedagogical and technological use in the teaching of the Grade 10 Physical Sciences topic of

Mechanics (research question 1). The findings reveal that the educators were on average at a developing stage in the effective use of ICTs when teaching Mechanics. The specific details of each case are in the research report.

The contextual variables that affect the pedagogical integration of ICT in the teaching of Mechanics (research question 2) in these three high schools, according to the participants, include policy or lack of it. The national and provincial policies offers few facts on how educators and schools are expected to incorporate or make use of ICT inside the South African framework.

Individual participants had different notions of the purpose of ICT integration. Mr Sibeko was of the notion that ICT integration was for planning efficiency of the whole school. In contrast, Mr Khumo was involved in ICT integration because the MEC or the higher authority had prescribed it. Ms Nomsa was involved because the school obtained ICT through a private sponsor and Mr Ariel just mentioned that ICT integration was "recommended" in the school.

The revelations from the findings were important in that *the TPACK rubric adapted provided measures that can be quantified and thus allowing the extent of TPACK to be statistically determined (using the Rasch Statistical Model) to a certain degree of consistency as measured by the Cronbach Alpha. One was able to determine if the participant was on standard, developing, elementary or inadequate. Furthermore each trait enabling or hindering was determined. This was unique to this study and will enable planners to determine areas where educators require assistance and support in ICT integration.*

The limitations of the research project are that in the original design I had intended to audiotape an initial (structured) interview and follow-up (unstructured) interview. This could have helped me to categorically capture the decisive moments such as apprehensions, facial expressions, stammering's and all the necessary registers of the discourse. Most educators were however of the view that they had time constraints. They suggested that the interviews be converted to questionnaires. Therefore the present structure might have created the impression of monotony of successive questionnaires.

Dedication

Glory is to God.

I would like to dedicate this research project to my mother **(Mrs Regina Mudindo)**; my late father said "look after the family long after I departed". You have done exactly that since the departure of Dad and I appreciate your dedication.

To my lovely sister **(Mrs Cortilda Mudindo - Tirivaviri)**

Your support is parallel to none, without you I would not be able to stand.

The Apostle Church in Rosettenville- South Africa, gave all the prayerful support during the whole process, and I am dedicating this thesis to you as well.

Acknowledgements

Doctor Megan Doidge: supervision par excellence; from you I have learnt the research skills, discipline and dedication required in this turf. Your skillful editing, check over the skills and clear understanding of the fundamentals of this research project has generated the construction of this whole thesis.

I appreciate the assistance from **Professors Judi Harris** of Maryland University in the USA, **Peter Twinning** from United Kingdom and **Fredriksson** from Sweden for navigating this ship in the right direction with constant inspiration which led to growth throughout. I thank you.

My deep appreciation for ***Doctor Reuben Dlamini*** your efforts together with my supervisor are much appreciated.

Associate Professor, Physics Samuel Ouma Oyoo: if it was not for you, I would not have had the opportunity to do this degree, and you were there from the beginning, sharing with me all your wisdom; your input has helped me to produce this thesis.

Professor Karin Brodie: Your determination and devotion in developing scholars is beyond generous.

Dr Elizabeth Mavhunga: your input in this study is based on the significant role in guiding me to appreciate the Rasch Statistical Model and analysis at honors level in-conjunction with the help of compatriot **Musawenkosi Ndlovu f**or refreshing the research concepts during this study, which became the cornerstone of this research project; your approaches forms part of the factors which have shaped my research project

The participants, principals, school governing boards of participating schools, heads of departments, learners and their parents who have availed themselves to complete various instruments: thank you so much; without you, there would be nothing to study.

Rona Mostert, Brighton Mudadigwa, Rudo Sithole, Farai Mukurunge, and Norman Muvhoti and Nhare: thank you very much for the role you have played in the entire process. I cherish such humanity and dedication.

Gugu Ncongwane, Paulina Makhenete and Lerato Mokoena: thank you very much for assisting with communication, between the University, myself and GDE

My family, friends and Comrades: I have reached this far in my academics together with you and your support is very much treasured.

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List of Acronyms

ICT	:	Information and Communication Technologies
GDE	:	Gauteng Department of Education
DBE	:	Department of Basic Education
GOL	:	Gauteng Online Project
TPACK	:	Technological Pedagogical and Content Knowledge
PCK	:	Pedagogical Content Knowledge
TSPCK	:	Topic Specific Pedagogical Content Knowledge
CK	:	Content Knowledge
PK	:	Pedagogical Knowledge
TK	:	Technological Knowledge
GUI	:	Graphical User Interfaces
PCK	:	Pedagogical Content Knowledge
TPK	:	Technological Pedagogical Knowledge
TCK	:	Technological Content Knowledge
MEC	:	Member of the Executive Committee
CAPS	:	Curriculum, Assessment Policy Statement
NCS	:	National Curriculum Statement

CHAPTER 1

Introduction to ICT Integration in Physical Sciences

This research study investigated ICT integration, with specific its state of inclusion in the teaching of the subject Physical Sciences, topic Mechanics, in schools in Gauteng province in South Africa. The importance of using a theoretical construct combining interplay of knowledge of technology, pedagogy and content knowledge in effective teaching and learning was explained in this chapter. The contextual variables associated with ICT integration by educators were discussed and the ramifications drawn in the South African context. More information was proffered on the rationality of the research project, its target, and various factors for its commencement presented. This chapter ended by spelling out the research questions, the researcher's positionality and the order of the research chapters in this report.

1.1 Contextual background to the study

The education fraternity in the world, as it is in South Africa, is caught in the digital age. Mdlongwa (2012) posited that Information and Communication Technologies (ICTs) are now part of the fabric in all our dominions of our life, from the workplace to the sports field, in schools and on a personal or social level. It is reasonable to say that in all facets and organizational aspects of our life, ICT has become indispensable. In the South African terrain, ICT integration in education and in the science classroom to be specific is described as "in its infancy" because the rest of the mechanism is involved in the "technical aspects" of the project (Dlamini, 2014).

The introduction of ICTs in schools in this 21st century is grounded on some of the reasons proffered by Voogt (2012), when he referred to ICT in education as for: social, vocational, pedagogic, catalytic, information technology industry, and for cost rationales. However, Voogt (2012) argued that there are really three key reasons for using ICT in schools which firstly is for: economic (vocational) – to make it possible to meet standards required for employment in the current information economy; secondly, social - to be able to fit, manage and participate freely in the society and at the work place; and lastly pedagogic (instruction) - to enhance teaching and learning.

In accordance with the principles of instruction (pedagogy), ICT has brought a different manifestation of the way learners learn and how teachers give knowledge to learners. Bingimlas (2009) states that the integration of ICT in schools offers opportunities for learners to acquire knowledge on how to function in the current information times.

The National Development Plan 2030 of South Africa states that quality education boosts changes in technology and modernization that is necessary to unravel present day difficulties. It therefore suggests that ICT be implemented if it can help to bring about quality education in its provinces (National Planning Commission, 2012, p23).

In this endeavor, the *Gauteng Department of Education (GDE)* has developed a five year strategic plan, with ICT as its fifth pillar out of the ten strategic pillars. Each pillar consists of change levers. Change levers are areas or aspects in which major changes ought to be observed and take place. ICT in education is described as a *change Lever - a* mechanism that would bring about major modifications. It is identified as *Lever 1* whose main target is mainstream schooling. This is envisaged to improve the quality of basic education through remodeling and creating state-of- the-art schools employing ICT (GDE, 2014). The current initiatives by the GDE are to provide tablets to 2 200 schools, this is in addition to the computers supplied under the *Gauteng Online Project (GOL)*, at a huge cost running into millions of Rands. Since these schools have received the Gauteng Online infrastructure, acquired Wi-Fi technology and the tablets from the GDE, the extent of ICT usage and its pedagogical implications needs to be assessed, especially in the Physical Science classroom.

Physical Sciences are considered as one of the most challenging subjects in the South African school system according to (DBE, 2012). Last year, the DBE 2015 examination report underlined the drop in matriculation for Physical Sciences as an area of worry (Equal Education, 2016). In 2014 the DBE stated that, although only 19% of all those who wrote matric had a mark considered a pass ranging 30% or greater, in Physical Sciences, learners who reached such a thirty percent threshold seemed to have enlarged from 48% in 2010 and to 62% in 2014 (DBE, 2014). This seeming rise in the Physical Sciences appearance is, according to a press release almost entirely as the result of an apparent reduction in the in the proportion of learners writing the examinations in the subject (Equal Education, 2016). The challenge in grade 12 might be a symptom of the content delivery problems not well presented in grade 10 in fundamental basic physics topics like mechanics.

Physical Sciences are described as one of the *“vital entryway subjects”* to post school opportunities in medicine, engineering and many other vital parts of the South African industrial complex. This is in addition to the fact that Physical Sciences are crucial to meeting minimum requirements to study towards a Bachelors or a diploma and open up a variety of science related post school opportunities including science university qualifications and therefore making the Physical Science mark the restricting subject to access science related varsity entrance. It is therefore worrying that only a small percentage of matriculates are writing and passing the subject.

1.2 Rationale

Learner results in the topic Mechanics in the Grade 12 examination have been established to be mainly poor, according to the DBE report on the National Senior Certificate Examinations (DBE, 2012). These are effects probably backdating to grade10 when the topic is first introduced. Poor results might be due to the fact that the concept of energy is highly abstract or intangible (for example concepts of energy: gravitational potential energy, kinetic energy, mechanical energy and conservation of mechanical energy – in the absence of dissipative forces). These are concepts learners cannot use their five senses easily to comprehend. Therefore, there might be a problem that learners tend to solve problems of Mechanics using monolithic procedures because of the complex nature of energy concepts and probably because of the way this concept is imparted and possibly because of poor comprehension of this topic by the educators.

The use of ICT during instruction has, in my opinion, the potential to simplify theoretical concepts involved in Mechanics to the level which the learner can understand, thus encouraging learning compared to old-style methods of “chalk and talk” and oral justifications.

Literature shows that ICT can play a very significant role in demonstrating scientific concepts in the topics of Physical Science by making them more reasonable and enabling learners to correct their own misconstructions on certain content specific topics, providing balanced and metacognitive frameworks, and finally improving learning results. Indeed, several academics have informed of positive effects of technology integrated involvements on learner accomplishments in mathematics, science, and other subject areas (Bliss, 1994; Liao, 1999 and Pearson and Naylor, 2006) and others.
The main reasons for doing this research is firstly, to establish the extent of pedagogical and technological use of ICTs by six selected educators in three approved high schools.

The three schools are part of the GDE 2 200 high schools in ownership of the ICT provisions. The focus of my research concerns the effective use of ICT in the teaching and implementation of the curriculum CAPS in the subject of Physical Sciences using the topic of Mechanics as an example. Secondly, I did examine the contextual variables that affect the pedagogical integration of ICT in these three Gauteng Department of Education (GDE) high schools in South Africa.

My interest in finding out the above issues was motivated among other things by trying to find out to what extent science departments in schools have been prepared in terms of materials and training by either the GDE or their own initiatives to be able to integrate ICT in the lessons of Physical Science.

1.3 Research problem and questions

The aim of my research was to gain insight into how ICTs are pedagogically used and the contextual variables that affect the instructional integration of ICTs in the GDE high schools in South Africa. Therefore, my two research questions were as follows:

1. To what extent was ICT integrated in the teaching of the Grade 10 Physical Sciences topic of Mechanics in three approved Gauteng High Schools?
2. What contextual variables affect the pedagogical integration of ICT in the teaching of Physical Sciences in these High Schools?

The research methodology implemented in this project was a mixed methods because it offered both the mathematical (quantitative) and expressive (qualitative) justification for the investigation. This research used the Technological Pedagogical and Content Knowledge (TPACK) framework as a lens for analysis in order to understand the extent to which ICT was integrated in the teaching of the Grade 10 Physical Sciences topic of Mechanics.

1.4 Theoretical construct: TPACK

This project was conceptualized within a new hypothetical construct called Technological Pedagogical Content Knowledge (**TPACK). TPACK** is a theoretical framework that is made up of three individual knowledge areas: firstly, content (CK), secondly, pedagogy (PK) and thirdly, technology (TK). **TPACK** describes how these knowledge areas function together to improve student enthusiasm and make physical science content (and other subjects too) manageable to learners (Mishra and Koehler, 2006). I did explain on the notions behind the theoretical construct in Chapter 2. It was envisaged that the findings of the study would contribute towards a better understanding of how **TPACK** functions.

1.5 Researcher's positionality

The research methodology adopted in this project was a mixed method as would be described in the third chapter of this research report. Qualitative researchers like Henning (2004) noted that the researcher should describe him or herself for the purpose of study and how his or her positionality influences the research project process. In the outline below I have tried to describe myself as a *(novice)* researcher and how my positionality may have a bearing on my research project.

I was born approximately at the center of Zimbabwe, a place located at the perennial river called Munyati (Munyati means *using one's brain wisely*). Munyati is an industrial area between the two towns of "gold", Kwe-Kwe and Kadoma. They are called the towns of gold because gold is easily found on the surface (alluvial) and is very accessible to a common man. The main place there is called Munyati ZESA (Zimbabwe Electricity Supply Authority) and located there is my birth-place.
The main activity is electricity production since 1938. We as friends from that area have always joked that we were born in "lights", "electricity" and "gold" since birth. The power station is coal fired. All my family and relatives work or have worked (various technical positions of production) for this power station except my mother (teacher at Catholic Schools) and myself now (an expatriate teacher). My late father worked for ZESA for 26yrs having arrived there in 1958.

Education, technology, religion and race diversification has been part of my life since birth. These four entities have shaped my life in many ways and it does not shock me that I have adapted very well in every country (including *South Africa the 7th*) that I have stayed for a short or long period.
I was educated in the finest private schools in Zimbabwe: Munyati ZESA (a company owned private school), Marist Shungu High School (a Catholic private school); Marist Kutama Mission (another private Catholic school famous for educating the longest-serving president of Zimbabwe and Africa) and Havana in Cuba for pedagogical studies. In 1989, I was at Marist Kutama which had since 1986, introduced computer science to us as a subject examined by Cambridge University of Great Britain.

In 1992 whilst I was a university student in Cuba, I bought my first computer (ACER 286) and have kept it until today.

As we grew up in primary school, the first industrial visit one would easily embark on was to visit the power station. In subsequent years, it became a routine to visit all its production processes. Then on special days, we would go into the power station with parents and relatives. Technology and love for science eventually was nurtured from these activities. I knew, for example, that I wanted to do chemistry since I was a toddler. I knew about "home grown" methods of gold extraction, now known as "gold panning" and from the power station I knew the coal treatment and purification of water. Stories and other narratives in the house and social circles were about the "going on" in this company or surrounding gold or tungsten related companies. As I grew up, I learnt to interact with different electrical gadgets when others were herding cattle for example. This entails the fact that most importantly, I did tend to adapt to change (shifts in technology trends, fashion and other things of life). I did not suffer colonialism as others went through. And my experiences are vastly different from the typical black African stories that are out there.

Lastly, but very important and close to my heart was the social make-up the area: consisted those of European origin (South Africans, English, Irish, Portuguese and others) and blacks (predominantly Malawi, Zambia, Mozambique and lastly Zimbabwe). My late father had a close association with all these people as a leader of the Catholic Church in the area. We as a family related well with everyone in terms of language (Chewa, Nyanja and English) and the various customs practiced by others.

It is possible that my interaction with the technology during my upbringing and to have grown up in an environment of numerical and narrative gold trade and values were order of the day might have generated a tendency to view issues both in quantification and narrative manner. This might have influenced my research structure and execution style of this research project.

1.6 The structure of the research report

This research project is made of six chapters, including this first opening chapter.

In chapter 2, I have gone through the literature on the nature of knowledge required by educators to teach effectively as espoused by Shulman and other researchers of Pedagogic theory, and then went on to unravel the new nature of the new theoretical construct that was used to integrate ICTs in teaching and learning (TPACK) and finally look at teaching and learning factors using TPACK in Mechanics.

In Chapter 3, I argue my research methodology: research mechanisms; data gathering; sampling and management; summary of the order of data gathering; analysis; validity and credibility; ethical issues and considerations. Chapter 4 describes the quantitative analysis carried out in this project using the TPACK rubric as an instrument for assessing the extent of ICT integration and the Rasch statistical model as the package for inquiry which did allow clarifying in detail how they integrate technology in the teaching design of the topic Mechanics.

In Chapter 5, I deliberate the results of the qualitative analysis of the responses from: initial-questionnaire; observations; the main questionnaire and finally the follow-up questionnaire that permits the six Physical Science educators to articulate how they integrate technology and the contextual variables that affect the pedagogical integration of ICT in the teaching of Mechanics. Finally, chapter 6 proffers a discussion of the implications of the study: that is the contribution to new knowledge; summary of research questions; conclusions and recommendations and critical reflections on the research process.

1.7 Conclusion remarks

This chapter dealt with the background reasons for studying one of the most challenging topics in Physical Sciences which cut across in the field of technical sciences, Mechanics. Among the reasons was to determine the extent of ICT integration in the schools and to explore the level of preparation. The rationale was based on the impact of observing how much schools had been resourced with ICT gadgets vis-à-vis learner results in topic Mechanics in specific and Physical Sciences in general. My position with respect to the research report was presented giving light on my administration of technology developments and finally influencing my research methodology which uses both numerical and expressive data (mixed methods).

1.8 Projection to the next chapter

The next chapter explains the literature related to the trajectory of the evolution of the theoretical construct and the discussion on the teacher aspect of the topic Mechanics used in this research project.

CHAPTER 2

LITERATURE REVIEW

This chapter deliberated on the literature related to the trajectory of the evolution of the theoretical construct TPACK. In this section I did depict the fundamental characteristics of the ***Technological Pedagogical Content Knowledge theoretical construct,*** *its historical underpinnings, the necessity to improve TPACK in contemporary educators, the technology required in the demonstration of content knowledge, the contextual variables affecting the theoretical construct, and teaching and learning features of the topic of Mechanics. I did illustrate using literature the interchange and interconnectedness' of pedagogy, content and technology, which, if combined efficiently in the teaching of physical sciences, would lead to effective teaching styles and learning of abstract concepts in this 21^st^ century.*

2.1 The underpinnings of the theoretical framework

A teaching subject like Physical Science is a context-related action and educators with established teaching knowledge scheme lessons tailor-made for particular pedagogies, fashioned for specific content, as situated in specific learning circumstances (Harris and Hofer, 2009). What teaching understanding should educators possess that contribute to real teaching and thus learning in current information age, one has therefore to glean the knowledge firstly in the area about teaching knowledge called Pedagogical Content Knowledge (PCK), a term introduced first by Shulman in 1986.

What is PCK? According to Shulman (1986), PCK includes

> *"The most useful forms of representation of [topics], the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others...Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons"(p 9).*

PCK dispenses with the notion of reducing Content Knowledge (CK) through attaining Pedagogical Knowledge (PK) to the level that "others" (which is the learner) could follow better.

Ever since Shulmans' PCK theory in 1986, it has been revealed that this type of knowledge, Pedagogical Content Knowledge (PCK) has been present in educators. The foundation of Shulman's conceptualization of PCK is the notion of changing subject content (*Topic Mechanics in my case*) for instruction purposes. There is evidence enough that PCK was capable of being more advanced in the educators' performance of duty. A comparison can be drawn between Physical Science novice and experienced teachers. Whilst the novice teachers grapple with the effects of the number of learners in the classroom, issues of discipline and class control act as impediments to content delivery (John, 2015). Experienced teachers do not view these as major problems because they know how to deal with these problems. Therefore, their level of content delivery was expected to be more efficient and effective. Therefore, this allows researchers to recognize affordances *(enablers that allow a goal to be accomplished)* of pedagogical strategies to the content (Harris and Hofer, 2009). In the Physical Sciences, PCK in electrochemistry, chemical equilibria, mole concept and other topics have been and some are still being measured by different researchers, including at this University of the Witwatersrand, where it is part of a bigger project (Mavhunga, 2012).

There have been a lot of investigations into PCK and its related concepts, and of late, there has been research on how best it can be measured or quantified (Ndlovu, Mavhunga, and Rollnick, 2013). Mavhunga and Rollnick (2011) outline the framework of topic specific pedagogical content knowledge (TSPCK) which proclaims that PCK was topic specific. This TSPCK was founded upon the concepts of transformation of topic specific concepts for instruction and was composed of the following factors: learner's prior knowledge, curricular saliency, what makes a topic easy or difficult to understand, representations including analogies and conceptual teaching strategies (Mavhunga and Rollnick, 2011). These factors could be quantified, including Content Knowledge.

It was anticipated that Content Knowledge was the precursor to the growth of PCK and the educators involve their knowledge to impart information (pedagogic) taking into account background issues, learner previous knowledge and information for learners in the improvement of the PCK (Shulman, 1987). Thus the following factors are integrated in PCK growth: learners when they are ready for coaching, they present themselves not as "blank slates" but have some minimum knowledge acquired before being introduced to a topic and this preceding understanding may be 'different' or may hold misconstructions (Driver, 1989). To successfully transform knowledge, the educator was in a good standing to do so if they are conscious of what his/her learners know then use this knowledge to support the learner into the gaining of new information. This way, the educator was best situated to be able to take care of these other conceptions and successfully eradicate misconstructions.

Curricular Saliency was the next factor of TSPCK and sheds light into the ability of the educators to successfully expose the major concepts in a topic and be able to share them to minor ideas. In this way a coherent sequencing of ideas, proofs and concepts are offered with proper direction that activates motivation in the learners and bond the new knowledge to other topics and daily application. Geddis and Wood (1997) noted that adherence to curricular saliency permits for appropriate decision on the deepness to which a topic ought to be imparted and the time management involved.

Correspondingly, it was of significant value that the educator has knowledge of what makes the learning of a particular topic easy or difficult. Effective PCK is revealed by the capacity of the educator to distinguish before topics of possible challenge and be able to clarify why they are challenging or easy for learners. This permits the educator to deal with the problematic areas and offer assistance that make comprehension of the topic to be easy on the part of the learners.

Further so, another significant feature in the improvement of PCK was the ability of the educator to use illustrations, similarities and prototypes to augment understanding. Ornek, Robison and Haugan, (2008) are of the opinion that learners, consider Physics concepts like Mechanics as problematic and abstract as they can be characterized as experiments, formulas, calculations, graphs and sometimes theoretical explanations that should be converted from one of these formats to another (interchangeably so).

Lastly, these academics, presents the idea of ‘teaching strategies’. These are the deliberations and the considerations that the educators have to manoeuvre in the progress of lesson provision. These are occurrences where the educator combines all the earlier mentioned aspects in the construction of PCK. In doing this, proper preparations of topic involve taking note of what should or should not be argued at a certain level of knowledge building. Analogies, representations and powerful examples are used to re- enforce the learning of a particular topic.

The interaction and connectedness of the five different aspects that have been expressed above are assumed to direct the improvement of TSPCK (Mavhunga, 2012). The magnitude to which the educator interrelates with these aspects ultimately defines the degree of TSPCK.

By means of this model some measurements of the framework were introduced which assist to explain quantitatively the degree of TSPCK in the educators (Mavhunga, 2012). Figure 1 below provides a complete outline of the several factors that was the building block of the Topic Specific Pedagogical Content Knowledge.

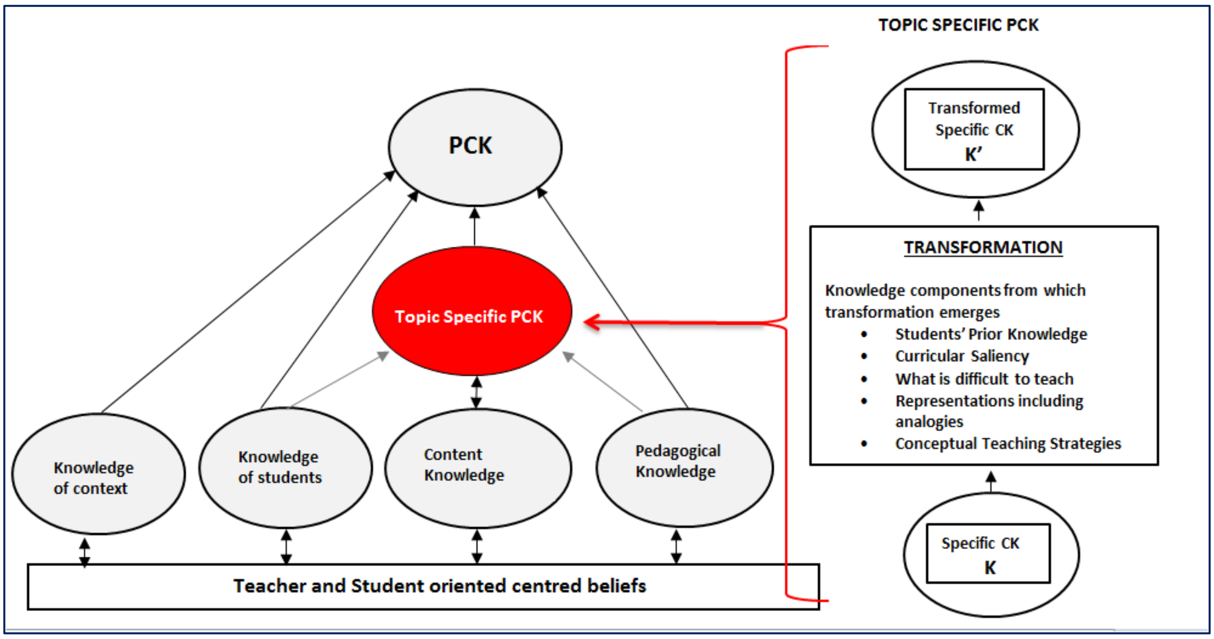

Figure 1: A model of Topic Specific PCK (Mavhunga 2012)

Although this PCK theory covers teaching knowledge more extensively, it was insufficient to theorize the occurrence of the 21st century Information and Communication Technology revolution. Albion, Jamieson-Proctor, and Finger (2010) proclaimed that even teacher education has been inhibited by using PCK put forward by Shulman early to the fluid nature of technological changes enabled by the internet. I agree with the above stated authors' view, because there was a need to move from the paper based industrial age outlook of schooling to a digital based paradigm which would be more appropriate for the information age of instructing. The theoretical concept of PCK was though highly significant in deliberating teachers' understanding about technology integration.

2.2 The evolution of the theoretical framework

Even though Shulman (1986) did not postulate technological knowledge in his pedagogical model, technology can play a very significant part in imparting scientific models when teaching topics of Physical Sciences to make them more comprehensive and tangible, helping learners to remedy their own misconstructions on certain content specific topics, providing rational and metacognitive supports, and eventually improving learning outcomes. Indeed, several researchers have reported positive effects of technology integrated interventions on student achievement in mathematics, science, and other subject areas.

Bayraktar (2002) investigated an across-the-board meta-analysis of the efficiency of ICT in science education in the United States between 1970 and 1999 to determine the general efficacy of ICT on learner accomplishments in secondary and college science education when equated to old-style teaching. He stated that secondary learners' attainments in science enhanced when ICT was employed. Bayraktar’s meta-analysis from 42 studies showed that a learners’ attainment level enhanced from the 50% to 62% percentage point when ICT was employed in science teaching.

Park, Khan and Petrina (2008) inquired about the effect of ICT (specifically physics) in science education had on the accomplishments of Korean middle school learners’ and established a major difference ($t(233) = 2.401$, $p = 0.017$) in the attainment level of the control and investigation class. This suggests that there was a substantial difference in pre- and post-attainment level of learners after the ICT-assisted coaching was employed.

Jimoyiannis and Komis (2001) gave helpful confirmation that the usage of computer simulations in physics teaching and learning was effective in nurturing learner’ attainment levels because they established a substantial difference between those learners’ who employed the usage of the simulation software and those who did not.

The National Science Foundation (2001) in the United States of America as cited in Rotbain, Marbach-Ad and Stavy (2008) offered proof that visualization tools such as animations can be employed to offer precise and rich depiction of the vibrant nature of molecules and molecular interaction, which are problematic to comprehend from the text-based expositions of information.
The positive effect of visualization was also corroborated in biological studies as applying in Physical Science concepts like Mechanics in my case as studied by Finkelstein, Perkins, Adams, Kohl and Podolefsky (2005) in their investigation of the effect of switching computer simulations on molecular interaction for laboratory equipment like molecular models.

Livingstone (2012) informed that a different technology, interactive whiteboards, was linked with an enhancement in learners' achievements in national tests in English (mainly for low-achieving learners and for writing), mathematics and science. Webb (2005) proposed an alternative path to bring about conceptual transformation in learners was by using ICT tools which are interactive and encompass graphical user interfaces (GUI) and scientific picturing for comprehension of concepts in science.

According to Khan (2005) cited in Park, Khan and Petrina (2008) *"computers can generate patterns, animate particles and processes, and display trends that trigger dissatisfaction with a prior concept, support the plausibility of a new idea, and suggest intelligibility and fruitfulness of this idea" (p6).* Therefore, there was a plethora of evidence from the literature that was supportive of ICT integration in Physical Sciences concepts that includes topic Mechanics learning and teaching.

Deriving from Shulman's (1986) view of pedagogical content knowledge (PCK), Mishra and Koehler (2006) and several other researchers (Niess, 2005; Angeli and Valanides, 2005) succeeded to come up with a ground-breaking theoretical framework of Technological Pedagogical Content Knowledge (TPCK) or (TPACK). I did use the term TPACK because of two reasons: firstly, the organization that represents this theoretical framework online is called "TPACK.org" and secondly, the founding researchers (Mishra and Kohler, 2006) of the construct call it "TPACK". The "A" on the wording seems to be for "And" or for some differentiation purposes on their website, whatever the case may be. Technological Pedagogical Content Knowledge (TPACK) attempts to offer insights into the nature of knowledge required by educators for technology integration in their teaching, while addressing the ramifications, and the most multipurpose and situated nature of teacher knowledge.

2.3 The conceptualization of the theoretical framework TPACK in the Research Project

TPACK is a theoretical framework that is composed of three combined knowledge areas: firstly, content (CK), secondly, pedagogy (PK) and thirdly, technology (TK) (Mishra and Koehler, 2006). This framework, represented in Figure 2, illuminates how these knowledge areas navigates together to increase student motivation and make physical science content like topic mechanics (*and other subjects too!!*) accessible to learners.

Content Knowledge (CK) in this research project refers to the subject matter of physical science that includes the theories (e.g. Dalton's Atomic Theory), principles (e.g. Archimedes principle, relating to buoyancy), concepts (e.g. Energy- the sum of gravitational potential energy (Ep) and kinetic energy (Ek) of an object at a certain time is known as the Mechanical energy, E) and laws (e.g. Newton's Universal Law of Gravity, Snell's Law of Refraction). Shulman (1986) expounded that Content Knowledge comprises innovations, proof, proof, recognized customs, practices and methods toward increasing such understanding.

Pedagogical Knowledge (PK) defines the art of "how" of teaching physical science. This encompasses the use of instructional skills like; investigation, deliberation, group debate, exhibiting and straight coaching. At the heart of this concept are content management techniques and delivery approaches to the learner by the educator. This component includes the comprehension of how learners acquire knowledge of the subject of physical science, general classroom and laboratory organization skills, lesson preparation, and student valuation. Essentially the skill of content conveyance (Koehler and Mishra, 2009).

Lastly, Technology Knowledge (TK) is theorized as an essential component tool to make physical science content and pedagogy approach to be sustained. At the centre of this concept is the capacity of the educators to select suitable technological tools for successful teaching and learning, both hardware (e.g. Laptops, smart board, camera, Pad, projector) and software (simulations, google, movie, edureactions, audio and virtual manipulatives).

There are intersections between Pedagogy, Content and Technology. Pedagogy overlaps with Content to form a knowledge known as *Pedagogical Content Knowledge (PCK)*. Technology joins with Content to form a knowledge area known as *Technological Content Knowledge (TCK)* and lastly, Technology and Pedagogy connects to form a another kind of knowledge known as *Technological Pedagogical Knowledge (TPK)*. These clusters of concepts put into perspective depict different ideas and ***affordances*** (*i.e. the relationship between the properties of an educational intervention like ICT and the characteristics of a learner that enable particular kinds of learning by him or her*).

In my view of the above, concepts about how to teach Physical Science alone was not sufficient. In addition the understanding of concepts, laws, principles and laws of physical science was also not adequate to help learners to comprehend effective. Therefore, I think educators necessitate supplementary knowledge on how to teach a specific topic like Mechanics content efficiently, i.e. educators need interplay of PCK, TCK and TPK.

Technological Content Knowledge (TCK) is a set of the interaction of knowledge. The understanding of how best one can choose the tools and resources to support learners to be inspired and learn specific features of the content (Mechanics) or curriculum (CAPS). It permits the identification of affordances of preparing applicable technologies (software and hardware) to the necessities of particular content (topic specific in our case) to be covered by educators. Educators need technological understanding about technologies and how to manoeuvre them efficiently for the advantage of reducing the content to the level the learner can understand best. Educators are required to comprehend which type of specific technologies are the most suitable for adapting to the difficulties of the concepts of Physical Sciences to be taught and how the topics difficulties or perhaps even changes the technology—or vice versa (Koehler and Mishra, 2009). This conceptualization wants to be synchronized with *Technological Pedagogical Knowledge (TPK).*
TPK is the concept of how to impart information successfully with these new digital technologies and tools. It encompasses a good comprehension of specific pedagogical approaches that permit or hamper the use of a collection or array of technological resources as they narrate to the dictates of the subject and developmentally finest suitable pedagogical strategies and methodologies (Koehler and Mishra, 2009).

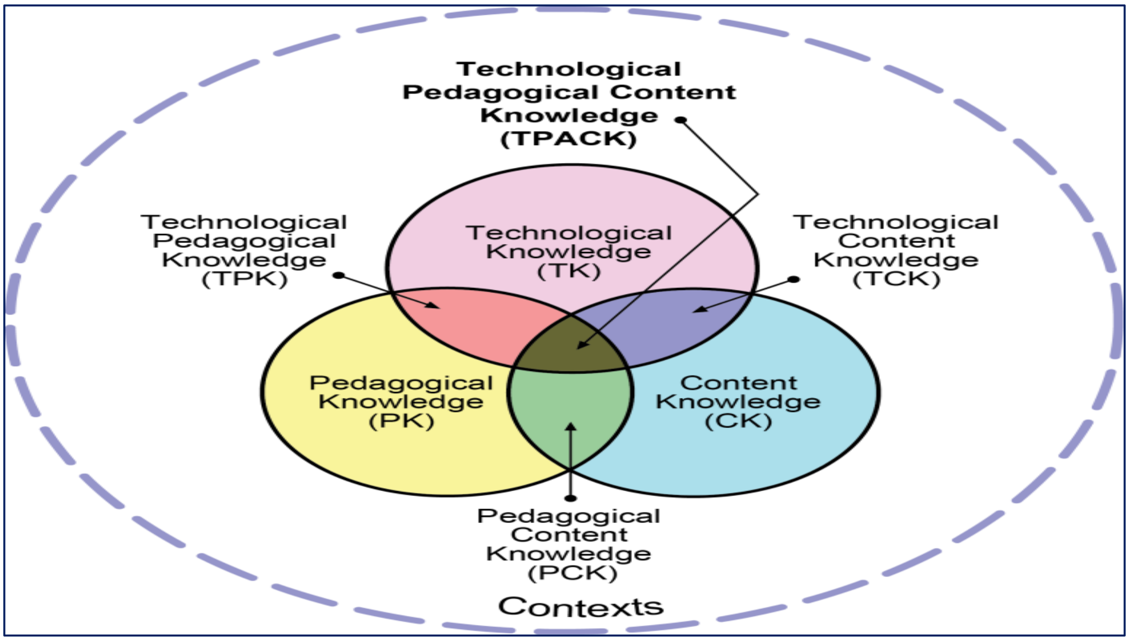

Figure 2: A theoretical framework for Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006)

All these overlapping and inter-reliant types of knowledge combined are considered to be ***TPACK***. This denotes the knowledge that educators necessitate to be capable to incorporate technologies effectively into learners' curriculum-based learning. ***TPACK*** is the fundamental part of all this understanding and is a different idea of the three types of concepts treated exclusively. ***TPACK*** is the underpinning conception of effective teaching and learning with technology. It needs a grasp of the skill of the illustration of scientific models, rules and philosophies using technologies; pedagogical approaches that apply digital resources in successful ways to impart scientific concepts; ideas on what makes physical science principles and laws hard or easy to learn and how technology can lessen most of the learners' comprehension problems in learning physical science; understanding of students' preceding knowledge and theories of epistemology; and facts of how technologies can be applied contextually to support on present understanding to build new epistemologies or reinforce the ones in existence now (Koehler and Mishra, 2009).

Thus the knowledge areas of the theoretical construct ***TPACK*** are visibly well-known as: Content (CK); Pedagogy (PK); Technology (TK); Pedagogical Content Knowledge (PCK); Technological Pedagogical Knowledge (TPK); and Technological Content Knowledge (TCK). These are knowledge areas underpinning what the educators need in order to incorporate technology efficiently into the learning and teachers' teaching.

2.4 Developing TPACK in modern educators

Mji and Makgato (2006) postulated that the lack of qualifications of most science teachers contributed to learners' poor performance. They pointed out that, according to the National Teacher Education Audit of 1996 in South Africa and the Mathematics and Science Audit of 1997, only 42% of the 84% of science educators professionally qualified are qualified in science. In these audits, the problem of inadequate training was particularly identified in the General Education Phase of the schooling system. The combination of all these factors (i.e. inadequate teacher training and poor understanding of physical science topics) have in turn produced a new generation of educators who are further extending the cycle of unevenness DBE (2001).

Therefore, these problems and the lack of sufficiently well-grounded educators with effective content and with laboratories to demonstrate some of the principles conceptually have raised the need to introduce ICT in the teaching of Physical Sciences. This was very apparent if one looks at the gap in preparing adequate lesson content of Physical Science when one was already struggling with being underqualified or trained. The budget or monetary constraints of using "paper" in printed books in teacher training (instead of digital) and the funding of laboratory buildings instead of virtual labs on a tablet.

South Africa's higher education institutions are according to John (2012) still only producing about half the educators needed every year. This problem of numbers can be alleviated through the use of ICT.

2.5 Teaching and Learning aspects of the topic of Mechanics

Ornek, Robison and Haugan (2008) are of the view that learners consider Physics concepts as difficult and nonconcrete because they are characterized as experiments, formulas, calculations, graphs and conceptual explanations that should be converted among them. The concept of the famous "Gravitational Potential Energy" was just one part of Mechanics that can be used to exemplify the complex convertibility of the concept and intangible nature of teaching this topic.

Firstly, the gravitational potential energy of an object was given *as a definition as* the energy that an object has because of its position in the Earth's gravitational field. It appears that the words "potential energy" was mostly used when the intent was rather "gravitational potential energy".

The concept gravitational potential energy can be *expressed secondly in symbolic form as Ep.*

Then thirdly, the same concept was *expressed as a formula or equation*: $Ep = mgh$ where Ep was gravitational potential energy measured in joule (J), m is the mass of the object measured in kilograms (kg), "g" is the gravitational acceleration measured in meter per second squared (m.s-2) and finally h as the vertical height above the point of reference measured in meters (m).

Then fourthly gain, the same concept was also *expressed as a conceptual explanation* as follows: The product mg in the equation Ep = mgh is a measurable force, that we call the Earth's gravitational attraction of the object or the weight of an object. This gravitational potential energy was thus the product of force and displacement and thus directly proportional to the force (weight) (Ep α mg) and also directly proportional the displacement (direct height) (Ep α h) from the point of reference (Near the earth's surface $g = 9.8\ m.s^{-2}$ because this value decreases with an increase in distance from the Earth's surface because the Earth's gravitational field and thus the gravitational force of attraction decreases with the increase in distance.)

Finally, these concepts are *transformed into experiments* where data and measurements are assembled and transformed into another concept known as graphs. *Graphing and interpretation* of graphs are introduced to the learner.

It was this transformational process of the concept, according to Ornek et al (2008), that makes Mechanics and its related theories seem too nonconcrete and problematic yet the theoretical construct ***TPACK*** is arguing that this can be simplified by the use of ICTs to make this whole lot of jargon understood conceptually, demonstrably and effectively with learners.

2.6 Technology knowledge required in the presentation of Content knowledge

There are different kinds of ICT lesson allied approaches and activities that can be applied by the educator in coaching the topic Mechanics (Harris and Hofer, 2009). An example of one type was called **Knowledge-building activities** *(see appendix A19)*. These activities can be carried out in Mechanics lessons with the help of technology to help learners build or construct knowledge. One of the activities under this category was simulation. Simulation was described as an activity where students engage in paper-based or digital experiences which mirror the complexity and open-ended nature of the real world (Harris and Hofer, 2009).. Using compatible technologies like virtual reality web sites, simulation software and animations a learner in my opinion have chances to comprehend better the subject matter. Other activities can be a question and answer where students respond to questions posed by the educator, other learners or workbooks. The appropriate compatible technologies selected to be used can be discussion boards, wikis, whiteboards, quiz and polling software and digital textbooks (Harris and Hofer, 2009).

The other types of activities that may be employed are **Procedural building activity types** *(see appendix A17)*. These activity types are a product-oriented knowledge in which the activity can be used to produce an artefact. In these activities, students create 3D or virtual artefacts. The compatible technologies that can be used are CAD/CAM software or virtual reality creation software (Harris and Hofer, 2009).

These alternative methods mentioned above of instruction using ICT, in my point of view, have potential to simplify nonrepresentational concepts involved in Mechanics to the level which the learner can understand, thus promoting learning compared to traditional methods of “chalk and talk” and oral explanations. Literature shows that ICT integration has the possibility to improve educational performance and effective school administration (Brown, 2004 and Jordan, 2005, both cited in Dlamini 2014).

In this endeavour the current MEC for Education in Gauteng has provided high broadband connectivity, e-books, 3D multimedia Smartboards, and each learner with a tablet and each educator with a laptop in schools in Thembisa, Mabopane and Duduza, townships in South Africa. He anticipates that these IT resources would be used within the classroom learning environment (MEC Education, 2015). It was consequently essential to comprehend how this type of technology was destined to be incorporated as intended.

2.7 Contextual variables affecting the theoretical construct

It becomes even more complex because this ***TPACK*** knowledge works in numerous settings where educators and learners work together. Many contextual influences exist that affect the effective teaching with these technological digital tools and resources. Therefore, knowledge of contexts was vital. This was the information of accessible technologies, the amount of time in ICT planning, cultural variety, language multiplicity, physical space, relational dynamics, societal economics, previous knowledge, locality anticipations, personal, learner information, geography, neighbourhoods and idiosyncrasies.
This was the reason why one can observe the dotted lines that surrounds the schematic diagram of the TPACK theoretical framework in section 2.3 (figure 2, page 15).

Mumtaz (2000) suggested that the features that affect the educators’ usage of Information and Communications Technology are 1) contact time with resources, 2) quality of software and hardware, 3) simplicity of use of both software and hardware, 4 enticements to change, 5) maintenance and collegiality in their school, 6) school and national polices guarantee of professional learning and, 7) experience in formal computer training.

In the European e-Learning Forum for Education (ELFE), Fredriksson, Jedeskog and Plomp (2007), stated that outside influence plays a significant role among aspects affecting ICT integration, and they classified them as follows: at the *macro level*, recommended in national programs and procedures objectives and purposes, usually referring to international inclinations and attractiveness and massive pressure from the information society. Factors at a *meso level* are located in schools.

Conditions, such as, the role of context and school ethos; inclination for change as well as guidance and supportive organizational environment have to be taken into consideration when analysing an implementation. At the *micro level, there* educators' pedagogical and technological abilities, size of the classroom, access to ICT and the number of students, are some of the components taken into consideration. Other aspects like classroom life and activities are part of the important context to take into account (Kozma, 2003 and Jedeskog, 2005).

Twining and McCormick (1999) on their findings on Learning Program: Developing teacher's ICT in Support of Learning, posited that besides all these initiatives costing millions in teaching and learning, there was considerable evidence that in the majority of schools ICTs are not being used extensively nor in the ways that enhanced children's learning.

Ndlovu and Lawrence (2012) citing results based on the Pan African Research Agenda (2008 – 2011) shed light into the state of ICT integration in South African school classrooms at that time.. They hold the view that ICT intervention has made little or no progress despite the availabilities of ICTs in the institutions. The reasons proffered are that the educators' in these schools are still in the phase of using ICTs to merely transmit subject content rather than use the technologies to improve learning. These educators need competence and innovativeness to maximize the potential of digital devices if their use improves thinking skills that are a significant component in enhancing learner performance.

Thus the implicit nature of the theoretical framework ***TPACK*** (Mishra and Koehler, 2006) makes it intricate, because one was dealing with the interplay and the intersections of concepts that educators' ought to possess for effective teaching and learning to be achieved using ICTs.

This research uses the TPACK theoretical construct as an analytical tool for understanding the extent to which ICT was integrated in the teaching of the Grade 10 Mechanics topic of Mechanics in these three High Schools and how educators make decisions about the use of Information and Communication Technology in their teaching *of the topic Mechanics in Physical Science* (Koehler and Mishra, 2009).

2.8 Conclusion remarks

This chapter dealt comprehensively with the background of the research project theoretical framework, its development from the PCK of Shulman to TPACK of Mishra and Kohler and finally its conceptualization in this research project. The ccontextual variables affecting and technology knowledge required in the presentation of Mechanics content knowledge discussed and how it might assist educators to reduce the abstract content of Physics in Mechanics to a level that can be understood by the learner. Teaching and Learning aspects of the topic of Mechanics on abstract concepts was discussed on how transformation of Physics concept evolved and finally the need in developing TPACK in modern educators argued.

2.9 Projection to the next chapter

The next chapter proffers the reasons for the design of the research project and the description of the rationale and the implementation of the selected research methodology in light of the objectives of the research project.

CHAPTER 3

Research Methodology

In this chapter, I started by giving a brief overview of the research process. This was followed by an outline of the legitimate reasons for the research design of the study. I described the rationale and the implementation of the selected research methodology in light of the objectives of the study. I discussed the origin of the tools used for data collection and the adaptation of the respective tools. I described how each set of data was collected in view of the issues of validity and legitimacy. I completed the chapter by giving considerations on the ethical procedures and limitations of the study.

3.1 Overview

I start this chapter by giving an overview of the commencement of this research project, and then discuss the legitimacy behind the research design. I show how the research design was linked to the selected theoretical framework and the research questions. I arranged the different aspects of the research design in the following sequence of significance: methods utilized in the research project and the rationale for using such methods, the origination of the tools used in the project and how they were adapted to our specific situation, the selection of research project sites, participants, verification processes, the data collection processes, the analysis, issues of validity and legitimacy, as well as ethical issues and limitations confronted in the study.

Firstly, at the end of completing my BSc (Hons) degree project in 2013, on measuring the quality of ***Topic Specific Pedagogical Content Knowledge (TSPCK)*** among experienced Physical Science teachers, teaching the topic of electrochemistry, I had noted two significant things - the strength of collaboration in research and the lack of inclusion of ICTs in the original PCK by Shulman and subsequent researchers (of this line at Wits University).

In preparing to conduct this research project, starting end of November 2014 I contacted researchers from other countries: Australia, United Kingdom, United States of America, Sweden and South Africa who are mostly authorities in project supervision or with expert knowledge in Education, PCK and ***TPACK***. I initiated discussions to do with their experiences in achieving successful research projects in the area of ***TPACK***, pertinent questions relevant to such a study, the tools they had used, the right of use of their materials and their availability to assist in areas where guidance was required. Some granted permission to use their materials and others did not. But I was satisfied with the numbers prepared to offer assistance to me.

In the first phase of early January to April 2015 I obtained tools that had been used by researchers alluded to above. My supervisor and an ICT specialist assisted in decision making on which tools to concentrate on in order to address the research topic and questions. I settled for the following tools: initial structured questionnaires (Appendix A3), observation schedules (Appendix A5 and A7), main questionnaire (Appendix A9) and follow up unstructured questionnaire - sometimes referred to as post-questionnaires (Appendix A11) The process of adapting the instruments to our specific situation was conducted with the help of the project supervisor and an ICT specialist who checked on the scope, length, time requirements and focus of each tool to ensure they addressed the project topic and research questions. In most cases I did refer back to these experts for verification and in most instances materials were scrutinized item by item and corrected or enhanced to be best suited for the research project.

3.2 Research Methodology

Educational research is derived from disciplines such as psychology, sociology, anthropology and philosophy. Therefore, it is classified under the main banner of Social Sciences. As Cohen, Manion and Morrison (2007) stated, in social sciences, there are two conceptions of social reality – suppositions of an ontological nature and a second set recognized as of an epistemological type. It is in good academic standing that the researcher appropriately defines his or her own ontological and epistemological expectations (Opie, 2004). It follows that due to these stated suppositions, there was a direct implications of the methodological concerns of the researcher. In the social sciences there are qualitative and quantitative studies that identify with the type of paradigm which the researcher chooses (Cohen et al., 2007). Cohen et al. suggested that qualitative research tools are predominantly associated with a researcher with a naturalist / subjective approach whilst quantitative research tools are associated with a positivist / objectivist approach. In my positionality expose in chapter one, I have stated clearly my standing which was not categorized in either or of the two exclusively. The research methodology to be used in this research project was Mixed Methods. The reasons for the decisions are described below.

3.2.1 Mixed Methods Research Design

A Mixed Methods research design is a procedure for collecting, analyzing and integrating both qualitative and quantitative research and methods in a single study to understand a research problem. The Mixed Methods research is within the pragmatist paradigm for the Mixed Methods research design that exhibits both post positivist (objective, deductive) and constructivist (inductive, multiple realities) philosophical approaches in confronting the research question (Creswell, 2012). In educational research, quantitative research requires the researcher deciding what to study; asks specific, narrow questions, collects quantifiable data from participants (a number of participants); analyzes these numbers using statistics; and conducts the inquiry in an unbiased, objective manner.

By contrast with qualitative research the researcher relies on the views of participants; asks broad, general questions; collects data consisting largely of words (or text) from participants; describes and analyzes these words for themes; and conducts the inquiry in a subjective, biased manner. As Fielding (2010) stated, researchers direct their attention to what is more feasible and best to answer the research problems. The purpose of employing Mixed Methods was to strengthen the reliability of data, the validity of the findings and recommendations, and to broaden and deepen our understanding of the processes through which program outcomes and impacts are achieved, and how these are affected by the context within which the research project was implemented. The reason for employing Mixed Methods comes from the recognition of the limitations of an exclusive dependence on either qualitative or quantitative methods, or the potential benefits that can be achieved when both approaches are appropriately combined Bamberger (2012).

The use of ICTs for learning and teaching was a new social phenomenon because originally these devices were not constructed with didactics as their main purpose. But due to massive investments in the ICT infrastructure for schools as seen elsewhere in the world and here in the Gauteng province in South Africa, Mixed Methods plays a crucial role in exploring the tacit nature and perceived complexity and the multifaceted factors identified within the construct ***TPACK***. The ability for teachers to conceptually explain their reasoning behind some of their teaching methods of Physical Sciences (Mavhunga, 2012), more so using ICTs was a complex matter. The internal processing of these methods was shown in different ways. These include how the educators select materials to integrate ICTs in every topic or sub-topic, the technology to use, the presentation, the talk during the presentation and the enactment of teaching instructions. To express this significant process as it manifests from planning and to enactment of teaching, narrative qualitative methods are thought to be best in harnessing and analyzing such events. In order to develop an insight of the extent of use of ICTs for pedagogical purposes, the observed occurrences in the application of certain technologies in observed lessons require numeric and statistical quantitative methods on the same data for analysis. Questions dealing with the validity and credibility of instruments to give an insight into the extent of use using the TPACK theoretical framework did require quantitative methods.

In my opinion, there is rarely a single evaluation methodology that can fully capture all of these complexities of the constructs due to the interplay of the knowledge areas as they operate in the real educational world. Creswell (2012) noted that there are two important characteristics of Mixed Methods designs: significance and arrangement. In research projects of this type one has the priority to give both methods equal weight, or determine if qualitative methods did have a higher weighting than the quantitative methods or vice-versa. The sequence refers to the order of collecting data – a determination can be made to collect both qualitative and quantitative data at the same time or collect quantitative data first, followed by qualitative data or vice-versa. Moran-Ellis, Alexander, Cronin, Dickinson, Fielding, Sleney and Thomas (2006) reasoned that using mixed methods, in an integrative style, entails that different methods are allocated equivalent values, and are, therefore, fundamentally mutually dependent, while retentive of their distinctiveness and functions. In this research project, quantitative and qualitative methods have been allocated equal quantification because both methods give an understanding similarly in as far as answering to the research question. Furthermore, none of the techniques follow a chronological order with one component evolving from, or following, the other.

The Mixed Method's design as employed in this research project occur in a convergent parallel design (Creswell, 2012) whereby qualitative data and quantitative data was collected concurrently firstly because of strict rules of research times allocated by GDE in their schools and secondly the need to analyze the two data sets separately then integrate the two data sets by merging the results during interpretation (and sometimes during data analysis). The purpose for employing this was to obtain a more complete understanding of this process from the two data sets and corroborate results from these two different methods. This Mixed Method's design not only meets the rationale, but was best suited to respond to the research problem. These methods are implemented within a research strategy known as a Case Study which is described below.

3.2.2 Case Study

In this research project the use of the case study as a strategy has been motivated by its close link to the Mixed Methods research design that seeks to investigate and report complex dynamic and unfolding interactions of events and other factors in unique processes. Furthermore, in view of the multifaceted and the tacit nature of the interplay in the theoretical concept of ***TPACK***, this approach permits focus on one or more aspects that deals with the 'intricacies and complexities' of the construct. Cohen et al (2007, p. 253) defines a Case Study as "a specific instance…. The single instance was of a bounded system and other contexts, which enable boundaries to be drawn around the case." The "specific instance" in this research project was the ICT integration by Physical Science educators in the lessons on the topic Mechanics in grade 10. These are qualified, experienced practicing Physical Science teachers whose schools have had an ICT infrastructure installed for pedagogical purposes. A case study was moreover labelled as being "limited structure." It may be limited by a set of chronological, geographical, organizational, institutional and other factors (Cohen et al, 2007). My research was being conducted in three Gauteng Department of Education (GDE) high schools in South Africa. These schools are involved in the ICT project of the GDE.

3.2.3 Sampling – The Setup

Purposive sampling was used to select two grade 10 Physical Sciences educators per school who claimed that they integrated ICT in their lessons. Their participation was voluntary. A purposive sampling method is sometimes called a verdict, discriminating or individual method, because the units of examination are grounded on the finding of the researcher. This allows the researcher to deliberate on people with specific features who were be better able to contribute with the appropriate research (Opie, 2004 and Cohen et al., 2011). These educators were observed over a period of two weeks. The curriculum we use is guided by the South African National Curriculum Statement (NCS) and the Curriculum, Assessment Policy Statement (CAPS) from the Department of Basic Education (DBE). All the schools concerned cater for township learners in the majority and all derive support from the Gauteng Department of Education and their parents' associations. The table below summarizes the qualifications and ICT experience of the participant educators

Table 1: The ICT Pedagogical data of the participant educators A9

School	A	A	B	B	C	C
PSEUDONYM	MR. ARIEL	MR JOHNS	MS NOMSA	MR KHUMO	MR ZUVA	MR SIBEKO
QUALIFICATIONS	ACE -Physical Science	BSC, PGCE Physical Science	BSc (Hons), ACE Physical Science	ACE B Ed Physical Science	BSC Science	B Ed
ICT EXPERIENCE	5 years	10 years	10 Years	12 years	7 years	6 years

The second part of the case required an insight into the contextual variables affecting the pedagogical integration of ICT in the teaching of Mechanics in these High Schools. The high schools as alluded to are part of the ICT integration project in Gauteng. They voluntarily agreed to allow access so that the research project could be conducted in their schools.

The table below offers characteristics of the High Schools outlined in the research project:

Table 2: The Characteristics of the sampled three Gauteng High Schools A9

Characteristics	School A	School B	School C
Type of School	Falls under the category of schools termed “ex-model C” schools.	Falls under the category of schools termed “ex-model C” schools	Purely a high density black township residence school.
Historical background of the school	High schools which in the past apartheid era were open only to the white communities.	High schools which in the past apartheid era were open only to the white communities.	This was open to blacks only.
State of the school	Known in the black community for their good facilities and linked with a high national matric results...	Known in the black community for their good facilities and linked with a high national matric results	The school was reasonably equipped infrastructural as all Mechanics lessons are conducted in ICT equipped science classrooms.
Logistics affecting the school	Considered a commuting school now	Low density residence category with some learners commuting, but both catering for majority learners from former disadvantaged black townships.	Learners live near the school.

These above characteristics mentioned in the table 2 are stable, unlikely to change during the term of the research project, as they have been defined in compliance with the DBE conditions.

A case study has the capability to focus attention on individual actors and seek their insights of events, but it must also be acknowledged that this strategy has its own weaknesses. According to Cohen et al (2007), results from a case study may not be generalizable, not easily open to crosschecking making them liable to bias and subjectivity and they are susceptible to problems of observer bias, despite attempts made to address reflexivity. The design of this study minimizes these disadvantages through the use of the Mixed Methods that produces both narrative (soft) and numeric (hard) data for analysis. The tools used in this research project and described below did assist in guiding how the Mixed Methods and the case study were applied.

3.3 Research Instruments

Mixed Methods research methodology utilizes both quantitative and qualitative data collection methodologies and in this research project a total of four (4) investigative tools were used: a, an initial questionnaire, the main questionnaire, an observation schedule and a follow-up questionnaire.

The questionnaire and the follow up questionnaire were authorized and adapted from the instruments by Twining and Henry (2012).

The Observation Schedule was made up of two parts, the first section adapted from Jamieson-Proctor, Finger and Albion (2010) and the second part adapted from *"Science Learning Activity Types" by* Blanchard, Harris and Hofer (2010*)*.

The initial Questionnaire was my own origination and design after going through the TPACK literature comprehensively.

3.3.1 Main Questionnaire

The main questionnaire (see Appendix A9) was designed to offer qualitative data before observations. The aim of the questionnaire was to collect basic background information and perceptions on the ICT situation across the sites of study from the six educators participating in the research. A questionnaire was one of the most used instruments for obtaining data in qualitative research, being able to be used without the presence of the researcher as stated in Cohen et al (2011). This manually distributed questionnaire was specified to obtain comprehensive information on ICT integration lesson mechanisms and the contextual variables affecting the process. The table below show questions and their justifications of used as used in conjunction with the other three instruments alluded to allow triangulation of results to be carried out effectively later.

Table 3: Justification of the Questions in the Main Questionnaire A11

Summarized questions	Rationale
1.1 The questionnaire started with a selection of a pseudonym by the educator in question	The reason was to comply with the ethical considerations on the principle of confidentiality and anonymity.
1.2 Confidence of use of ICTs and competence!	The data were used to determine how much the educator rated him or herself
1.3 To indicate the technological devices accessible when at home	This was to give insight on the level of attitude or motivation to acquire ICT devices for personal use that can be used for pedagogical purposes.
1.4 Probed on the involvement of any of the educators in any stage of implementation of their site.	To determine the level of inclusivity in the planning and implementation of the ICT project.
2 Establishing for how long in the site ICT project has been going on	This was a question intended to unpack contextual variables associated with the reasons behind the implementation.
3 Work undertaken in the Physical Science department to implement ICTs and barriers experienced	This was to give insight on context impacting implementation associated with the level of preparation of science educators, the acquisition of soft and hardware etc.
4 The lessons learnt during the ICT integration project	Give insight into contextual variables affecting implementation?
5 What do educators in different sites experience and what advice would they give to other Physical Sciences teachers starting off a similar project in the science department?	Offer Insight into contextual variables as viewed by individuals on what worked or what did not function during and after implementation (their reflections on the process)

3.3.2 Initial questionnaire

This initial structured questionnaire (see Appendix A3) provides both qualitative and quantitative data and all the responses would be used to describe the process and at the same time the data set was be scored or rated against a ***TPACK rubric***. The aim of the initial questionnaire was for the educators in every site of the research project to appraise the researcher on how he/she does the process of preparation to integrate ICT in the teaching of Mechanics before the actual lesson observations took place.

Table 4: Justification of the initial Questionnaire A3

Question	Rationale
1 What approach do you use during lesson preparation to teach the topic of Mechanics using ICT?	This question did give insight into the instructional strategies to be employed by the educators in writing as part of a TPACK assessment scoring.
2 Which software is used to teach mechanics and how are they selected, if not part of the standard tablet package?	This gives informed view on the ease or complex use of software and its suitability for the purpose of teaching Mechanics.
3. Where do you source the software or technologies for teaching Mechanics?	This allows comprehending the ease and complex issues of acquisition of the software or hardware and the knowledge of service providers of the ICT project.
4 How do you merge or sort the content that is be taught and the type of technology that is be used by them to have a coherent and meaningful lesson?	These give an insight into the FIT (content, pedagogy and technology) integration level of the educator as part of a TPACK assessment scoring.
5 Is there any difference in the time that it took for you to prepare for a traditional lesson compared to now when you have integrated ICT into your teaching?' Elaborate.	Time factor- preparation for a traditional lesson compared to ICT integrated.
6 What other activities are done to achieve meaningful lessons besides the above mentioned?	Soliciting information on other activities allows the researcher to determine the ease of technology selection and Curriculum goals with technology selection ability (as part of a TPACK assessment scoring)
7 To what extent has the training that you received from the (DoE) or (Name provider--) to use ICT in the classroom been useful (i) for your lesson preparation, and (ii) with teaching your topic during class?	To probe on the prior training situation the (DoE) or GDE or any service provider. To give an insight if the training was useful for the lesson preparation and teaching any topic, during Mechanics lessons.

After being appraised on how the participants go through the process of preparation to integrate ICT in the teaching of Mechanics before the actual lessons this allowed the researcher to prepare and evaluate if what the participants described was actually happening. A comprehensive observation schedule was used to evaluate the lessons as described below.

3.3.3 Observation Schedule

The observation schedule (see Appendix A5 and A7) gives both qualitative and quantitative data sets relevant to the focus of study. The observation schedules are the most frequently used instruments for obtaining information during observations (Opie, 2004). An observation schedule was chosen because one was able to discern ongoing behavior as it occurs and can take valuable notes about the salient features that one was researching (Cohen, Manion, and Morrison, 2011).

To answer the research questions, teachers were observed during their teaching of the grade 10 Physical Sciences topic of Mechanics (energy) to understand the extent of ICT integration. These schedules allowed me to look at the level of alignment between the information extracted in the initial questionnaires and the observations made within the classroom. Observation provides a guard against over-reporting (Hintze and Matthews, 2004). The observation schedule had part A and Part B.

The first part (Observation A) dealt with 6 observations, three of which are shown in table 3.5 below. The field notes on the researcher's observations were recorded in the "Comments" column for each lesson observed. These notes involved assessing the type of digital technologies being used with the focus of determining if they aligned with the curriculum goals. The questions would also give insight into the level of technology selection(s) by the educator and how these keep the learners fixed to the objectives of lesson topic Mechanics.

The researcher used the observation schedule to synchronize what the educators claimed they do in the lesson and what they actually do. The level of FIT (content, pedagogy and technology) combined together was determined as the content, presentation, the art of instruction and the selection and use of technology. These were compared with what the participants responded in the initial questionnaire schedule.

Table 5: Observation A: Technology Knowledge - Digital Technologies A5

Observation	Technology Knowledge - Digital Technologies	Comments
1	What digital technologies are being used?	
2	Is he/she comfortable using digital technologies?	
3	Does he/she keep the class captivated by these digital technologies?	

In observing a mechanics science lesson I as a researcher has to have categories of science specific categories that I look for in a participant that allows a categorization to be arrived at, whether the participant used ICT integration successfully. Therefore below are the extracts of science specific activities, strategies and relevant technologies that are involved in teaching the topic Mechanics which forms part of the attributes that ought to be measured. These science specific strategy forms the second part (Observation B) part of the observing schedule that dealt with the Science Learning

Activity Types (*see appendices A7a-c)* which are classified as conceptual teaching strategies, Knowledge Building Activities, Knowledge Expression Activity types, and Procedural Knowledge Building Activity types. The researcher checked if these technologies with these strategies were used by the participant more often or occasionally and if not at all. The table below shows an extract of Conceptual Knowledge Building Activity participants was observed for and the rate of use:

Table 6: Conceptual Knowledge building activities A7b and A8

Activity Type	Brief Description	Possible Technologies	Often	Occasionally	None
Read Text	Learners acquire data from texts, workrooms, etc.; Both print-based and digital layouts	Web sites, electronic books, online databases, magazines			
Attend to Presentation/ Demonstration	Learners obtain data from educators, guest speakers, and peers; in individual or via video, oral or multimedia	Presentation software, document camera, video			
Take Notes	Learners store information from lessons, exhibition, group work	Word processing software, wiki, concept mapping software			

The table below shows an extract of activities and strategies, participants were observed for and the rate of use to develop procedural knowledge concepts during the teaching and learning of Mechanics

Table 7: Procedural Knowledge building activity types A7a and A8

Activity Type	Brief Description	Possible Technologies	Often	Occasionally	None
Learn and Practice Safety Procedures	Learners learn how to safely and appropriately handles equipment	Video clips, document camera			
Measure	Learners learn how to make measurements appropriately with specific tools (e.g., Graduated cylinder, motion sensor)	Probe ware, content-specific interactive tools (e.g., Explore Science)			
Practice	Learners practice using equipment, software, measuring, testing what they have designed, etc.	Web-based software or software tutorials, probe ware, document camera			

The table below shows an extract of activities and strategies a participant was observed for and the rate of use:

Table 8: Knowledge Expression activity A7c and A8

Activity Type	Brief Description	Possible Technologies	Often	Occasionally	None
Respond to questions	learners answer to educator-distributed, peer-written, printed, or digitally modelled requests (e.g., That necessitates small responses, clarifications, or explanations)	Curriculum, software, word processing software, quiz software, Web sites, online discussion forum			

Using the observation tool (for each lesson) allowed me to qualitatively describe the extent of use of ICTs by teachers and also use the same data set to quantify how much each participant differ from the other. This was achieved by taking down the notes on the salient use of the technology and ticking to determine the frequency of use of any activity type and its corresponding technology. These would assist in the scoring of the participant performance using the ***TPACK rubric***.

Finally the last tool was a follow up questionnaire which was used to mop up the research areas as described below.

3.3.4 Follow-up (unstructured) follow-up questionnaire

The follow-up questionnaire (Appendix A11) was done after the initial questionnaire, lesson observations and the questionnaire have been responding to, to allow the researcher to fill in the gaps that might have surfaced during these processes. The follow up questionnaire was structured in such a way as to provide both qualitative and quantitative data that would strengthen the analysis and results proffered by the other three tools used in this research project early on.

Table 9: Justification of the follow up questionnaire A11, A12

Question	Rationale
1 Do you think this ICT Integration project should continue?	This question solicited a straight answer that would determine if participants' attitudes towards ICT integration were negative or positive.
2 If you answered YES to 1, how do you envisage it will develop?	The responses in this section are expected to give light as to the core contextual reason on beliefs and attitudes towards ICT integration.
3 If you answered NO to 1, why not?	Same as in Question 2.
3.2 Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?	Solicit lesson preparation to be scored on a TPACK rubric to assess extent of pedagogical application of technology.
4 Are there any factors that may help or hinder the continuation?	Sought to understand contextual variables on the positive or negative that affect ICT integration.
5 What impact has the ICT Integration project had on educator staff?	This question intended to further unlock attitudes and beliefs towards ICT integration.
6 What impact has the ICT Integration project had on the implementation of Caps in Physical Science in your school?	TPACK theoretical construct is for the Curriculum based content, this question intended to solicit directly the educators thinking with regards to curriculum goals with technologies.
7 What impact has the ICT Integration project had on your pedagogy?	The responses would allow determining the level of pedagogy on FIT (content, pedagogy and technology) component of the TPACK rubric assessment.
8 What impact do you think the ICT Integration project had on your pupils?	The response to this question was be used to determine the educator thinking on his use of technology as a motivational tool on Instructional strategy component when assessed on TPACK rubric.
9 What other impacts has the ICT Integration project had?	This question was intended as a reflective thinking of the whole ICT integration in the Science classroom. Any valuable reflection of the process allowed the researcher to appreciate or not the extent of ICT integration.

3.4 Data Collection

The logistics involved in the data collection in this research project were profound because the schools were far apart and therefore data collection had to be planned meticulously to allow (i) a planned tool like questionnaires to be administered to all participants during their different free times but during school hours. Some participants were given tools before school begins, during break, and others during a free lesson or after school and (ii) class observations to be done every day as timetabled in all the given sites selected for this research project (iii) duplicating enough copies of the research tools to be done (iv) constant communication with the project sites and participants to ensure their presence or any unforeseen circumstances to be addressed. Therefore a sizeable amount of personal financial budget was set aside to allow modalities of this data collection possible in an acceptable university time limit to allow the completion of the study.

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3.4.1 Summary of the Sequence of Data Collection

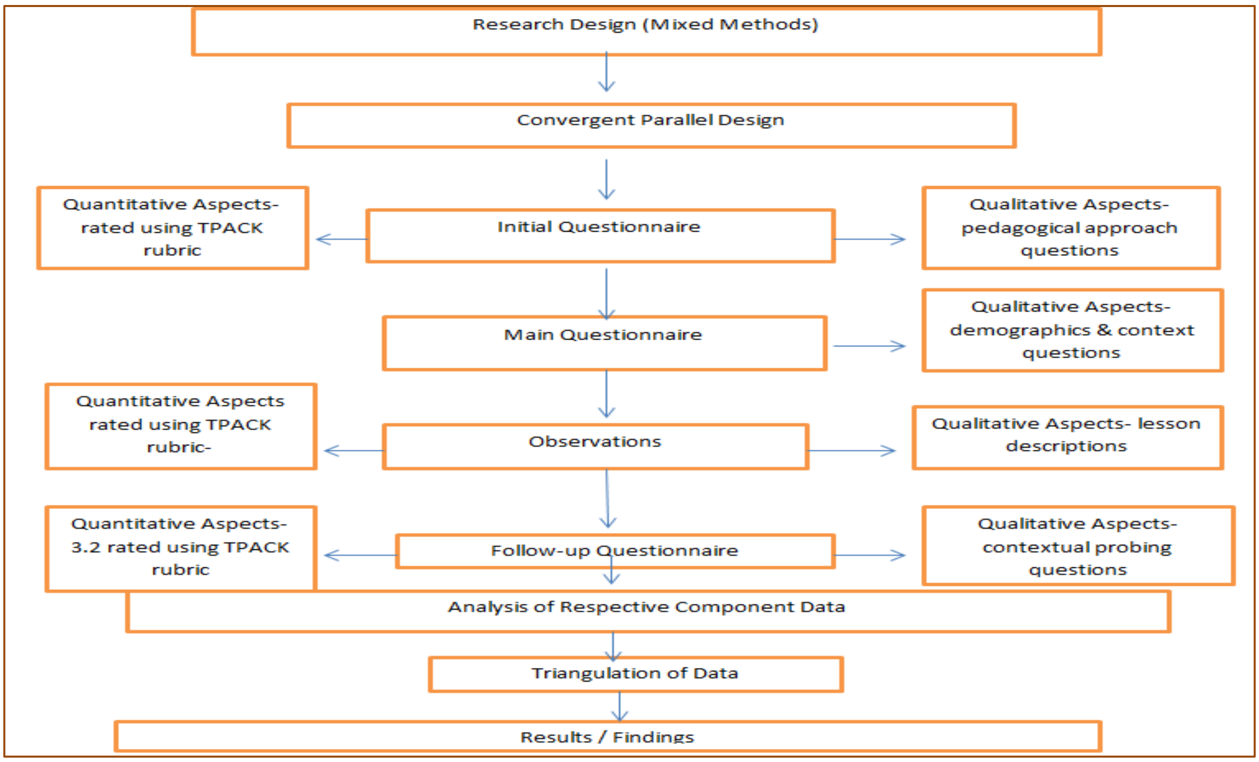


Figure 3: The sequence of data collection and analysis to the point of triangulation

3.4.2 Initial questionnaire

The first tool to be administered was the initial (structured) questionnaire. In high schools A and B the participants did not consent to being audiotaped whilst being interviewed. After negotiation a settlement was reached whereby, I gave them the questions in paper form and they would write down the answers without being necessarily audio-taped. According to ethics principles a participant cannot be coerced into an act which they did not want to engage and furthermore they have the right to withdraw from the research project at any given level. The latter conditions I did not even want to contemplate about them. According to Cohen et al (2007) one of the strengths of a case study was that it can embrace and build in unanticipated events and uncontrolled variables. This was being addressed in the ethical issues appropriately in *section 3.8.* In high school C they consented to the interviews being audiotaped but for uniformity sake, we did make a decision that they write on paper as others had done in view of the constraints of time. The teachers were given ample time, a maximum of two hours if they so wished. After answering I collected the scripts and thanked them for their participation and left for another school and repeated the same process the same day. All scripts were collected and kept according to the ethics procedures.

3.4.3 Main questionnaire

According to best practice, questionnaires that ask descriptive and behavioral questions about the professional development experiences have been shown to have good validity and reliability scores Mayer (1999). The second tool was a questionnaire which was administered four days after the initial questionnaire. The participants were now more relaxed and at ease. Participants were given a maximum of two hours to answer the questionnaire. I am conscious that when questionnaires are administered in a social setting such as face-to-face situation, the presence of the researcher has an effect on the behavior of the participants towards providing pleasing information (Cronk and West, 2002). On the other hand, the presence, and specifically the supervision provided by the researcher during the administration of customary instruments, encourages the completion of the instrument. Once completed in one high school another was approached according to the site plan until every participant was covered.

3.4.4 Observations

Observations were the main significant strategy of capturing and measuring the extent of use of ICTs during the teaching of the topic Mechanics in grade 10. Observations were the tangible method that did give an insight into Physical Science classroom context and the actual contextual variables affecting the integration of ICTs in a normal lesson set-up. A maximum of 10 working days was dedicated to making these class observations in all schools. According to Cohen et al (2007) a case study captures exceptional characteristics that may be missing in huge scale obtained information; these distinctive features might hold the clue to understanding the condition. Observations within this strategy provide just that, a unique data gathering where one was able to discern ongoing behavior as it occurs and are able to take appropriate notes about participants' salient behavior. After nine days all the observations had been completed and I arranged with the participants to participate in the final tool – the follow-up questionnaire.

3.4.5 Follow-up questionnaire

Hard and soft copies of lesson plans, class activities and notes made by teachers were availed to me during their lessons. In some cases I had questions about the whole ICT integration process or issues to do with the planning of lessons other than the one of Mechanics observed. A follow-up questionnaire was designed to achieve that aim. According to my research design this was an act of a "mop-up" exercise which participants could use a maximum of 2 hours if necessary
Because the above mentioned methods of collecting data were comprehensive, they provided a rich source of data from the quantitative and qualitative research methods of the study. This enabled triangulation, therefore lessening the weaknesses of each method or any prejudice associated with a monolithic method.

3.5 Analysis

In this research project I opted to carry out an analysis, designed for Mixed Methods - the gathering of data for the qualitative and quantitative data sets was designed to take place simultaneously because both types of data have equal value for understanding and responding to the research questions. The design allowed me to collect both types of data in each visit to the research sites. This type of data collection proved to me to be natural and efficient for this type of set-up. Data from each of the methods was analyzed with special precaution to relate appropriate analysis methods to the nature of the construct being used as a lens for measurement.

3.5.1 Quantitative Analysis of the TPACK data

To achieve quantitative analysis of the theoretical construct, according to Harris, Grandgenett and Hofer (2010), there are three types of data that can be used to assess teachers' ***TPACK***. These are self-report (via questionnaires, surveys, or other generated documents, such as reflexive journal entries), observed behavior, and teaching artifacts, such as lesson plans.

The responses from the initial questionnaire (the whole tool), the summarized two week results of observed lessons, and question 3.2 on the follow-up questionnaire were first scored, respectively, using a ***TPACK rubric*** (*Table 12*) by the researcher (FM- Fumai Mudindo) and the independent rater and referred to section 4.5 for full analysis.

MR ARIEL TPACK EVALUATION

1. What approach do you use during lesson preparation to teach the topic of Mechanics using ICT?

- Mechanics is visual
- A student will excel if he can see what he is working with.

2. Which software do use and how do you identify this type of software for the purpose of teaching Mechanics if not part of standard tablet package?

- Auto Cad
- PowerPoint
- Java
- Need to experiment and see what works for individuals

3. Where do you source the software or technologies for teaching Mechanics?

- Personal or Computer Technicians

4. How do you merge or set the content that will be taught and the type of technology will be used them to have a coherent and meaningful lesson?

- I research the topics and see which workshop best fits the topic than merge them.

5. Is there any difference in the time that it took for you to prepare for a traditional lesson compared to now when you have integrated ICT into your teaching? Elaborate.

- Yes, it takes more time now as PowerPoint takes time to iron out the problems and the time but once it is done you can use it and edit whenever.

6. What other activities are done to achieve meaningful lessons besides the above mentioned?

Practical time in workshops help stimulate the students.

7. To what extent has the training that you received from the (DoE) or (Name provider…….) to use ICT in the classroom been useful (i) for you lesson preparation, and (ii) with teaching your topic during class?

•I never received training.

8. OBSERVATIONS SCORES

Activity Types	*Often*	*Occasionally*	*None*
40	*18*	*9*	*13*

9. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

- Research it. • Download videos from YouTube.
- Choose a workshop best suiting the topic. • Create a PowerPoint Presentation.
- Look at it as chess and anticipate questions and answers for students.
- Show them practicals.

Assessment: Researcher / [redacted] (cancel the inapplicable)

Classifications	Curriculum Goals & Technologies	Technology Selection(s)	Instructional Strategies & Technologies	FIT(Content, Pedagogy & Technology together)
Assessment	2	2	2	1

Figure 4: An extract of Mr Ariel's Response Assessment (TPACK) Schedule A21 – A26

The observation schedule, section B, consisted of 40 science specific strategies in the teaching of topic Mechanics (see appendix A7a-c) whose frequency of use was being observed. This would allow the researcher to determine which strategies were being used frequently, occasionally or none at all. This allowed the researcher to ask participants in the follow up questionnaires as to why some strategies were used more than others. Also, this allowed the researcher to determine with certainty, technology selection, compatibility of technology selected with the CAPS objectives to be taught in mechanics. In doing so it informed the scoring process together with the other aspects of the questionnaire tools mentioned above. Mr Ariel had 30 strategies which he did not use at all and these were mostly in the procedural building activity types and conceptual building activity types. This meant that the learners were more subjected to knowledge expression activity types. This in Mechanics, ICT integration reflects the inadequacy of effectively using ICT integration. By comparison Mr Zuva used almost all strategies in the two week period. His lessons enjoyed multiple angles of presentation to learners that amounts to a successful ICT integration.

The ***TPACK rubric*** was designed to have four different categories that assess the degree of the complex, situated, and interdependent nature of teachers' technology integration knowledge:

♦ ***Curriculum Goals and Technologies (Curriculum-based technology use);***
♦ ***Instructional Strategies and Technologies (Using technology in teaching/ learning);***
♦ ***Technology Selection(s) (Compatibility with curriculum goals and instructional strategies) and***
♦ ***Fit (Content, pedagogy and technology together).***

More details on ***TPACK assessment scores*** of participants was be provided in the analysis chapters with examples.

The rubric scores were open to validation from the independent rater who was familiar with the Physical Sciences topic specific measures working in the science education field with research interest in ICTs. The rater familiarized with the tool and the rubric. The generated scores were then analyzed, using ***the Rasch statistical model.*** First, the Rasch statistical model was used to confirm the validity of the tool. Next, the data standardized in research are analyzed for significance differences between responses. The functionality of the Rasch statistical model was provided in the analysis chapters.

3.5.2 Qualitative Analysis of the TPACK data

For analytical purposes, designed for the qualitative aspect of collecting data, the questionnaire allows the participants to introduce themselves to the context of study by stating their preferred pseudonym which did guarantee non-identification of their persons. The rest of the questions comprise of Likert Scale type and open-ended questions very rich in qualitative description of contextual issues concerning ICT integration. The initial (structured) questionnaire was probing questions that allowed qualitative descriptions that gave insight to the internal processes of lesson planning and external intricacies that makes an ICT integrated lesson possible. The observation tool complemented the other tool in that seeing a process in itself unfolding was descriptive in nature. It allows checks and balances of what the participants claim to and the actual act of their doings. Finally the follow-up questionnaire closes the research project by inquisitive questions which are open-ended in nature that allows qualitative data to be gathered on whether ICT integration should continue being implemented or not and how it should be recommended to take off in other contexts.

Furthermore, all these methods provided opportunities for elaborated explanations for ICT integration.

3.6 Validity and Credibility

When data sets from different sources converge and agree this increases the validity and credibility of findings or interpretation. When different data sets are not consistent, the researcher explores further to understand the reason for the inconsistencies. Cohen et al (2007) stated that validity was a demonstration that a particular instrument measures what it purports to measure and Lincoln and Guba (1985) suggested that the term reliability be replaced with the term credibility in particular the notion of dependability in qualitative and quantitative research. The sections described below are intended to give a clear picture of the qualitative and quantitative components inbuilt checks and balances applied throughout the planning, data collection, and analysis of data from different tools in light of the two aspects: validity and credibility.

3.6.1 Designed for the Quantitative data aspect

The statistical data of the original instruments adapted for the research project established a solid internal validity *ab initio* (from the beginning): Cohen et al (2007) argued that internal validity seeks to show that the explanation of a particular event, issue or set of data which is a piece of research provides can actually be sustained by the data. The rubric scores were open to validation from the independent rater who was familiar with the Mechanics topic specific 2010;

The table below, refers to the confirmed statistical validity done by the developers of the original instruments (tools) used in the research project.

Table 10: Original Statistical Reliability and Validity of Instruments: (Blanchard, Harris and Hofer (2010); Jamieson- Proctor, Finger and Albion (2010)

Statistical Reliability	Intra-class Correlation Coefficient	Interrater reliability – Percent Agreement	Internal consistency - Cronbach's Alpha	Test-Retest Agreement
Observation tool	0.802	90.8%	0.914	93.9%
Questionnaire tool	0.870	91.7%	0.895	100%.
TPACK Rubric	0.857	84.1%	0.911	87.0%

♦ Intra-class Correlation Coefficient is an assessment of consistency or reproducibility of quantitative measurements made by different observers measuring the same quantity. Therefore the greater correlation, the higher the degree of acceptability of reproducing the same results. Thus it used to assess conformity among observers (Gadermann, Guhn and Zumbo, 2012).
♦ Interrater reliability represents the extent to which the data collected in a study are deemed correct representations of the variables measured. Thus, it assesses the degree of agreement among raters (Mc Hugh, 2012).
♦ Internal Consistency – Cronbach's alpha measures whether several items or categories that intend to measure the identical general construct, produce similar assessments (Gadermann et al (2012).).
♦ Test- Retest Agreement is considered in statistics to be the most common measure of reliability. It refers to the measure of the level to which assessment results are stable over a given period. This is a difference measurement taken by a single instrument at the similar time, under the similar conditions, and in a short period (Mc Hugh, 2012)

The source of these tools used in establishing the extent of pedagogical and technological use of ICT's in selected educators' gives firm credibility from the origination of the tool. Although the wording in the tools used in this research project was adapted to suit local situation, the original objectives of the tools remained intact and unchanged. Hence, the data from the ***TPACK analysis*** of the research project even subjected to a different research, statistical model would confirm and strengthen the validity and credibility of the quantitative findings of this research project.

3.6.2 Designed for the Qualitative data aspect

Cohen et al (2007) states that it is very easy to fall into invalidity as it is both sneaky and malignant as it can percolate at every level of the investigation. To avoid this during the qualitative data design and collection: starting with the initial (structured) questionnaires and follow-up questionnaires, the schedules were deliberated upon by the supervisor and the ICT specialist both for content, length and focus. I did, the answer the questionnaires myself before their finalization and exhaustive deliberations were made. There was a paper trail in the form of various designs kept by the supervisors and myself which shows the developmental stages of adaptation and implementation of these tools. The main tool which was the observation tool was adapted from the well-researched science specific activity types aligned to the main ***TPACK construct***, describing each expected activity type, brief description of the activity and the possible technologies that apply. The adaptation done by me according to the focus of the research was to add the columns on the extent to which the activity was used or developed during the teaching of topic Mechanics. The tool would allow descriptive analysis (as well as quantitative) of how the ICT integration was observed in its natural settings and compare to the theoretical descriptions given by the participants on how they prepare and conceptualize their lesson integration. The tool maintained its quantitative validity and credibility as described above in 3.6.1. The analysis chapter would offer more on the research project tools.

3.7 Reflexivity

In section 1.6 of Chapter one, I stated my positionality with respect to the methodology to the research project because Ezzy (2002, p. 153) indicated that "the personal knowledge of the researcher was an essential portion of the research procedure." This was very explicit in light of integral inclinations and partialities the researcher might have in looking for implications from the information collected during the research process, and this was termed as reflexivity. In this research project I have tried to be conscious of my locus during the data gathering and made continuous ideas in writing to my supervisor on how I was arrriving at decisions and constructing evaluations of the data. I valued the assessments of my supervisor who would randomly inquire and check the process of collection of data. I also respected the remarks and elucidations made during the triangulation procedure as they sought to establish if the assessment was suitable and fair during the coding of the answers used for the ***TPACK ratings***. McCormick and James contended that fighting reactivity through reflexivity necessitates researchers to monitor carefully and frequently their own interfaces with participants, their own responses, functions, preconceptions and any other aspects that might affect the research project. Issues of validity and credibility have been dealt with but other issues dealt with the ethical issues of the research design as described below.

3.8 Ethical Issues

Prior to the conducting of the research project I did meet the conditions stipulated by the University's Human Research Ethics Committee (Education) - 2015ECE022M *(Appendix A1: Ethics letter of approval)* that I had done everything possible to ensure proper *informed consent, anonymity and confidentiality* of the participants.

The GDE satisfied itself with the conduct proposal of my research and authorized the research to be carried out in their schools (see Appendix A2). The research project was designed on the foundation of regular principles governing educational research among them that the participation would be *voluntary* and the participants had *a right to informed consent*. The research was essentially concentrated on the educators, but due to ethical concerns, the learners too were considered to be participants as their presence in the Mechanics lessons was considered vital. An appointment and information session was planned otherwise for each set of participants according to their site situation (distances and availability). The educators were did participate voluntarily. For learners it was a case whereby each educator chooses one class convenient to them for the purposes of the study.

Thus, learners essentially had to follow their usual school guidelines for the period of the research project. The ethics specify that researchers ought to avoid placing the participants in a situation whereby they might be in risk of harm- *principle of non- maleficence*- (either physical, psychological, financial, legal or social) as a result of their involvement. The study contained no possible of physical harm to the participants, as they continued in class as per normal procedure. For the psychological factor, the *principle of confidentiality* was employed in order to help guard the discretion of research participants. I used pseudonyms to safeguard the identity of educators participating in the research. The name of the school and its contact details were not be distributed or transcribed openly. The data is kept in electronic form with passwords known only to the researcher. The scripts are kept and stored by supervisors at Wits and destroyed after 3-5 years. For the learners I called them “learners” for purpose of this study as it focuses on educators only. Information folders containing an account of the project and approval forms for the principal, the educators of the concerned classes, the learners and the parents were provided *(see appendices A12-A18).*

Adler and Lerman (2003) submitted that investigation, mostly in the settings of emerging nations, involves an assortment of responsibilities or purposes , and proprietorship of the participants, the researcher and his or her location, and the people. The foremost benefactors of this research project are Gauteng Department of Education because of two things- firstly GDE wants to know from research the extent of pedagogical use of their vast investment in the ICT integration project (paperless classroom thrust) and secondly their teachers need to be given the evidence that ICT can make their lessons more interesting, easier, fun for them and their learners, enjoyable and more motivating. The other beneficiaries are be the international ***TPACK.org*** which I am a member to add knowledge on ***TPACK*** construct from an African context and the science education community at large, through digitization of the thesis and to make it available through the electronic-library system. Although my research did not directly benefit the learners in the school who participated, I consider that it would benefit forthcoming generations of learners as educator preparation programs advance their contribution, informed by the results of the study.

3.9 Reflections

My research methods were designed to measure firstly the extent of pedagogical and technological use of ICTs in these six selected educators, who are part of the GDE 2 200 high schools in possession of the ICT provisions by using the following criteria: Curriculum Goals and Technologies- (Curriculum-based technology use), Instructional Strategies and Technologies- (Using technology in teaching/ learning), Technology Selection(s)- (Compatibility with curriculum goals and instructional strategies) and “Fit”- (Content, pedagogy and technology together) and secondly, to examine the contextual variables that affect the pedagogical integration of ICT in these three Gauteng Department of Education (GDE) high schools in South Africa. I have taken care to minimize my biases as discussed in this research project. The participants rejected completely to follow the order of my research design by refusing to be audio-taped for the initial and follow up questionnaires rather opting for writing responses. The prospective trust and mutual aid between the researcher and the respondent was viewed as solid in face-to-face meetings (Dooley 2001). I recognize that I was enthusiastic about the study, and to see colleagues science educators transitioning with great effort from traditional ‘chalk and board’ to high tech paperless board, with its potential impact on the South African context. These sentiments may obscure my assessments and certain facets of the analysis. I also acknowledge that the data collected during school practice were only for duration of two weeks and for a solitary topic; I am aware of this, in addition to the restrictive aggregate sample size, as one of the practical limitations of the research project.

3.10 Conclusion remarks

One of the aims of the research preparation is to assemble an effective method that captures the essence of the phenomena to be investigated. In this chapter the Mixed Methods research methodology was selected based on the intricacies of the process of ICT integration which is not only pedagogically new but has a tendency to evolve fast. Therefore both narrative (descriptive) method and numerical method was essential for the design of a study involving ICT integration. An aspect like gold, fast changing in value or trade but whose narrative spans over centuries. Educators actions had to be captured, the responses captured and all these converted to numerical values that could be quantified and offer an opportunity of comparison. The chapter finally ends with ethical issues in which both learners and educators had to be protected.

3.11 Projection to the next chapter

The next chapter deals with the Quantitative analysis using the **TPACK rubric** and the **Rasch Statistical Model**, how they were used towards responding to Question One of the research project and discussing the significance of the results

CHAPTER 4

Quantitative Analysis of the Extent of ICT Applications using TPACK

The previous chapters dealt with the introductory rudiments of the theoretical framework ***TPACK****, its locus standi within the educational, scientific literature and culminating in a comprehensive research methodology for this research project. In this chapter I discussed the* ***TPACK rubric*** *and the* ***Rasch statistical model****, how they were used towards responding to Question 1 - the determination of the extent of effective use of ICTs for pedagogical and technological use in the teaching of the Grade 10 Physical Sciences topic of Mechanics by six educators in three high schools in Gauteng province, South Africa. The instruments used for data collection were called Data Collection Tools) and the* ***TPACK rubric*** *and* ***Rasch statistical model package*** *was referred to as the Analytical Instruments. Finally, I provided the significance of the findings.*

4.1 Overview

The aim of this project was to collect data of educators integration of ICT's in teaching topic of Mechanics in Grade 10 Physical Sciences in three approved South African High Schools. The obtained data in the sequence as shown in Figure 5 was analyzed quantitatively to determine the educators' extent of effective use of ICTs for pedagogical use in Mechanics. The quantitative analysis was composed of the aspects shaded in light green in Figure 5 shown below

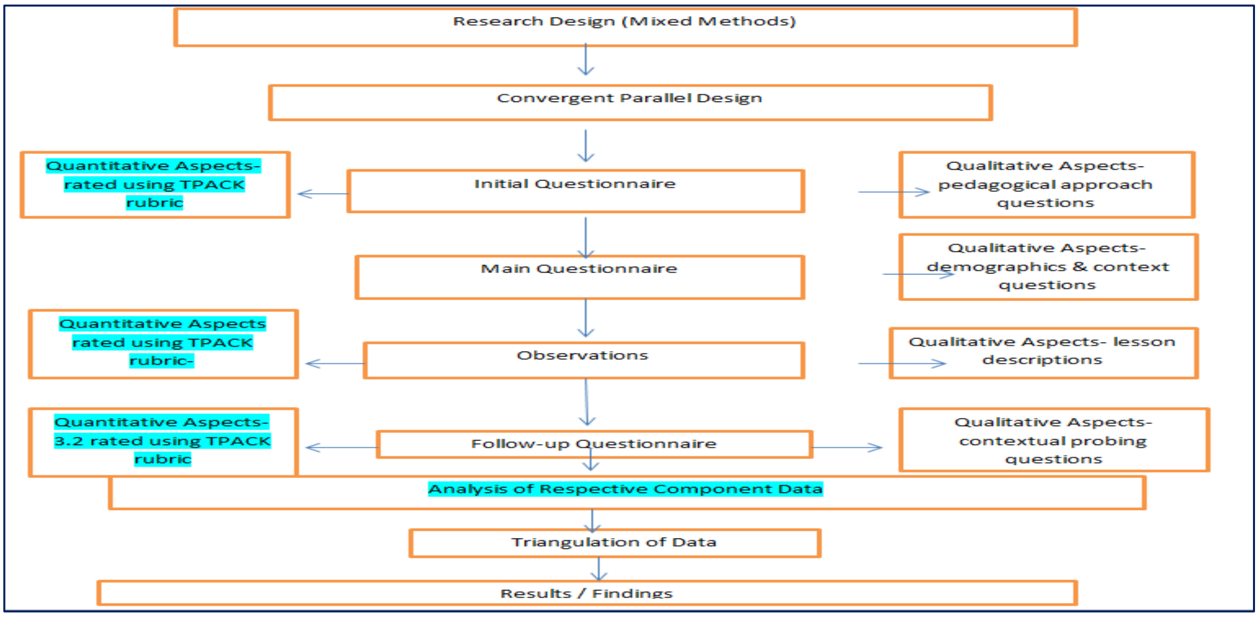


Figure 5: Sequence of Quantitative data collection

As outlined above, the first analysis feedback was obtained from the initial questionnaire *(see appendix A3)*, where participants were asked questions relating to technology selection, instructional strategies, or pedagogical approaches, as well as software and hardware all aligned to the curriculum goals to do with the topic Mechanics. The responses from these questions became part of the Response Assessment Schedules *(see appendix A21- A26)* that were assessed using the ***TPAC rubric*** (*Table 12*).

The second analysis feedback was provided for the data obtained during a two week topic Mechanics class observation. During that observation period the following procedure was undertaken: the researcher sits down with each participant and obtains information on what they normally say they use during their ICT integration. The Observation Schedule allows this sort of arrangement to take place first as the researcher did tick on the schedule what the participant claim to use in his or her lessons. The second step involves the actual two week observation, whereby as the researcher, I was ascertaining if what the participant alluded to was actually being employed or done and with what technological integrations (This was the reason table extracts 3-6 to 3-8 were inducted earlier on in chapter 3 for the reader to understand that there are science specific TPACK activities which constitute successful ICT integration in Mechanics – the ability to try to measure this and make a comparable analysis was what allows the research to determine the levels of TPACK. This was a new approach introduced by this approach and might fit the traditional view point).

The observation schedule *(see appendix A5)* was composed of the first section (*Observation A*) of a checklist of questions which the researcher had to respond to in the form of notes taken down during ICT integration lessons of all participants. The second section (*Observation B-see Appendix 7 summary of observations per each category of Appendices A7a-c*) consisted of ticking the checklist of three component strategies (knowledge expression, conceptual knowledge and procedural building activities) that were being observed if they were applied often, occasionally or none at all as participants had alluded to in the beginning. These notes and ticked checklist were be combined with the responses from the initial questionnaire alluded above to make a combined Response Schedules that were assessed using the ***TPAC rubric***.

There was a clear guidance for what consist knowledge expression strategies/ activities (*sees appendix A7a*), conceptual knowledge activities (*see appendix A7b*) and procedural building strategies/ activity types (*see Appendix 7c*) respectively. The combined or aggregated results of all each observed activities in each category from Appendices A7a-c forms the summary of observed results which was Appendix 8.

Using Appendix 6 one was able to view in which categories of activities did the lessons of the participant was strongly in ICT integration (in conceptual knowledge activities, knowledge expression strategies or procedural building strategies/ activity types). One was able to come out with a comparison of what participants alluded to before, during observations and in the questionnaires. These observations allow comparisons to be undertaken between educators on the topic of Mechanics. If a participant had more of none in all the categories of observations obviously a participant with more observed occasional use in all the categories was given a fair balance in the areas of instructional strategies and this was deemed as doing very well in comparison to none. We expect that from the initial stages of the topic building until the conclusions on the topic, there be a balance in ICT integration activities or strategies.

A summary table of results from observations is below:

Table 11: Observation Results: (Appendix 8)

TPACK: Observations on Activities Summary Results			
	Knowledge Expression strategies / Activities	Conceptual Knowledge Activities	Procedural Building Strategies
Total score per Activity	**12**	**17**	**11**
Participant			
Mr Ariel	4	3	2
Mr Johns	10	10	6
Mr Sibeko	6	4	3
Ms Nomsa	8	6	3
Mr Khumo	8	7	4
Mr Zuva	10	13	8

Finally the last analysis feedback was from question 3.2 of the follow-up questionnaire *(see appendix A11 and 12)* that requested the educators to choose a topic of their own choice and explain how they would integrate ICTs. The response from this question would show from the educators, knowledge of content curriculum aligned topics and goals, technology selection(s), pedagogy and instruction skills. These responses formed the final part of the Response Schedule that was assessed using the ***TPAC rubric***.

The whole set up was structured in such a way that the researcher at all the given moments would be located in the classroom and sometimes in the laboratories or preparation rooms to get to understand from in situ the whole integration process in their science lessons to allow proper and accurate pedagogical integration assessment of ICTs. The obtained data were subjected to the **TPACK rubric** assessment which is described below.

4.2 Classifications used to determine the extent of ICT use using TPACK Rubric

The responses from the Initial questionnaires, observations and follow-up questionnaire were rated using the TPACK rubric. The TPACK rubric was an assessment tool that allows measurements of the theoretical construct: TPACK (*Figure 2 p 15*) to be undertaken. The theoretical construct as alluded to consist of the following attributes Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK) and Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and all of these fusing to form the Technological and Pedagogical Content Knowledge (TPACK).
Each class in the TPACK rubric shows the knowledge components of TPACK required to achieve effective learning integrating ICTs.

Table 12: TPACK RUBRIC adapted from Harris, Grandgennet and Hofer (2011)

Class	Criteria	4 (Standard)	3 (Developing)	2 (Elementary)	1 (Inadequate)
A **TK, PK and CK**	*Curriculum Goals and Technologies (Curriculum-based technology use)*	Technologies selected for use in the instructional plan are strongly aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are partially aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are not aligned with any curriculum goals.
B **PK, TPK, TCK and PCK**	*Instructional Strategies and Technologies (Using technology in teaching/ learning)*	Technology use optimally supports instructional strategies	Technology use supports instructional strategies	Technology use minimally supports instructional strategies	Technology use does not support instructional strategies

C **TK, TPK, TCK**	*Technology Selection(s) (Compatibility with curriculum goals and instructional strategies)*	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies	Technology selection(s) are appropriate, given curriculum goal(s) and instructional strategies	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies
D **TPACK**	*"Fit" (Content, pedagogy and technology together)*	Content, instructional strategies and technology fit together strongly to within the instructional plan-CAPS)	Content, instructional strategies and technology fit together within the instructional plan	Content, instructional strategies and technology fit together somewhat within the instructional plan	Content, instructional strategies and technology do not fit together within the instructional plan

This was an instrument designed by Harris, Grandgenett and Hofer (2010) to assess the educators' extent of effective use of ICTs for pedagogical purposes. The instrument was adapted (the original had no scoring system – *scoring was my own initiative*) with the aim of quantifying pedagogical attributes of each participant required for analysis of performance allowing comparison. (Messick, 1989). Messick claims that validity is an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions **based on test scores**.

The *Response Assessment (TPACK) Schedule* contains information that was descriptive in nature and hence the adapted **TPACK rubric** seeks to give a quantitative value that can be used in the measurement. Hence the responses were then assessed according to the levels given in the **TPACK rubric.** The **TPACK rubric** consists of four classes (A to D) as shown above that reflect the effective use of ICTs for teaching and learning using a system of scoring (1 – 4) for assessment and for providing relevant meaning to the scores for the purposes of this research project. **TPACK rubric** used as alluded to has been validated as described in **section 3.6.1**.

4.3 Quantitative Analysis of TPACK Classifications

The **TPACK rubric** was thus used to convert the responses from the narrative nature contained in data collection tools on the project to quantitative data. To get a better understanding of the conversion I shall explain each class and attempt to show how the responses were analyzed and how the quantitative marks were apportioned.

4.3.1 CLASS A: Curriculum Goals and Technologies (Curriculum-based technology use)

In education, a curriculum (or curricula) was a concept that encompasses goals, methods, materials and assessments for learning and teaching (Hidden curriculum, 2014). In this research project, a curriculum essentially refers to the lessons and academic content, concepts and skills imparted in schools or in specific courses or programs. Curriculum goals are the known benchmarks or expectations for teaching and learning, often made explicit in the form of a scope and sequence of skills to be addressed. The content, concepts and skills for teaching Mechanics includes the ability to list physical quantities, differentiating between vectors and scalar quantities, definition of mechanical terms, calculation of physical quantities like distance and displacement, description of graphs and stating laws like the conservation of energy and applying mechanical principles *(see appendix A20)*

The South African curriculum as alluded to in chapter 3 was known as the National Curriculum Statement. The curriculums goals for Mechanics and other subjects are contained in a document know as Curriculum, Assessment Policy Statement (Caps) - *(see appendix A20).* The topic Mechanics teaching aims, concepts and skills are located in the Caps document and an extract are presented in the table Figure 6 below:

TERM 4 GRADE 10

GRADE 10 PHYSICS *(MECHANICS)* TERM 4

Time	Topics Grade 10	Content, Concepts & Skills	Practical Activities	Resource Material	Guidelines for Teachers
8 HOURS	<u>Energy:</u>				
1.5 hours	Gravitational potential Energy	• Define gravitational potential energy of an object as the energy it has because of its position in the gravitational field relative to some reference point • Determine the gravitational potential energy of an object using $E_P = mgh$			Fundamentally, there are only two kinds of energy viz. potential and kinetic (excluding rest mass energy). Inform learners that $g = 9{,}8\,m{\cdot}s^{-2}$ and that this will be further studied in grade 11 and 12. This value is used to calculate gravitational potential energy
1.5 hours	Kinetic energy	• Define kinetic energy as the energy an object possess as a result of its motion • Determine the kinetic energy of an object using $E_K = \frac{1}{2}mv^2$			Introduce kinetic energy as the energy an object has because of its motion. The same notation used for kinetic and potential energy in Physics, will also be used for those concepts in Chemistry.

PHYSICAL SCIENCES GRADES 10-12

Figure 6: An extract of Content, Concepts and Skills for top Mechanics in Grade 10 Caps document A20

In all class categories of the TPACK rubric (table 4-12) the Observation scores are the only components whose determination were done by the researcher-using Observations A (in form of personal notes/records and B (science specific TPACK strategies in form of a checklist whose results are depicted by Appendix 8) but the rest of the components were subjected to independent rating because in obtaining verifiable participant ICT Integration skills required that information be recorded in writing form in the absence of audiotaping or visual recoding a condition the participants refused.

TPACK theoretical construct is curriculum based and hence the TPACK rubric measurements are based on a given curriculum that was already in existence like the NCS and its CAPS component. Every educator in this project tries to teach Mechanics as defined according to NCS and hence CAPS directs the expected content to be delivered.

Technology is referred to as knowledge of techniques, processes, skills; methods embedded in machines, computers, electronic devices which can be operated by individuals without at times detailed knowledge of the workings of such things (Thesaurus Dictionary, 2016). Curriculum based technologies are those hard and soft wares configured for the accomplishments of the objectives of the educational disciplines including Physical Sciences or in other words for pedagogical purposes. Firstly, to award scores, Class A of the TPACK rubric seeks to establish the extent of technologies selected by the participants for use in teaching of Mechanics lessons during the two week observation period if they strongly align with one or more curriculum goals or to a lesser extent the other criteria mentioned below:

Table 13: Rubric Criteria for Curriculum Goals and Technologies

CLASS	*Criteria*	4	3	2	1
A **TK, PK and CK**	*Curriculum Goals and Technologies (Curriculum-based technology use)*	Technologies selected for use in the instructional plan are strongly aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are partially aligned with one or more Curriculum goals.	Technologies selected for use in the instructional plan are not aligned with any curriculum goals.

Secondly the researcher verified during that particular period if participant's independent descriptions of an ICT integrated instructional or lesson plan was a result of experience of ICT integration or it was just to satisfy the request of the demands of the questionnaire (question 3.2 of the follow-up questionnaire).

Therefore the TPACK scores on this category were based on the initial descriptions of technology selection as required by questions 1 - 6 in the initial questionnaire. Since both the researcher and the participant are privy to the content, in this initial questionnaire one was be judged from how one purports to select and use them (technologies), then this was corroborated by an actual observation for a period of two weeks if the participant really does did as the plan alluded to (*Appendix A7-A8*) and lastly the verification of knowledge to select technologies for a Mechanics lesson other that of Mechanics was used as a judgement tool to determine if the participant would have the possibility of successful selecting technologies to integrate in a lesson of Mechanics.

The three tools would be used in the scoring using the criteria in the extraction of the rubric shown above (table 8). In the broader part of the theoretical construct, one would be showing three knowledge areas of TPACK (TK, PK and CK). The results are summarized below:

Table 14: Scores for Curriculum Goals and Technologies

	DERIVATION OF TPACK SCORES FOR CLASS A: Curriculum Goals and Technologies			
Participant	Initial Questionnaire	Observation Schedule	Follow-up Questionnaire	Final Score
Mr Ariel	**2**	**2**	**2**	**2**
Mr Johns	**3**	**3**	**3**	**3**
Mr Zuva	**4**	**4**	**4**	**4**
Mr Sibeko	**3**	**3**	**3**	**3**
Ms Nomsa	**3**	**3**	**3**	**3**
Mr Khumo	**3**	**3**	**3**	**3**

Mr Johns is an example of an educator who was scored with an average of 3 in Classification A. His extract from Q2 of the initial questionnaire is shown below:

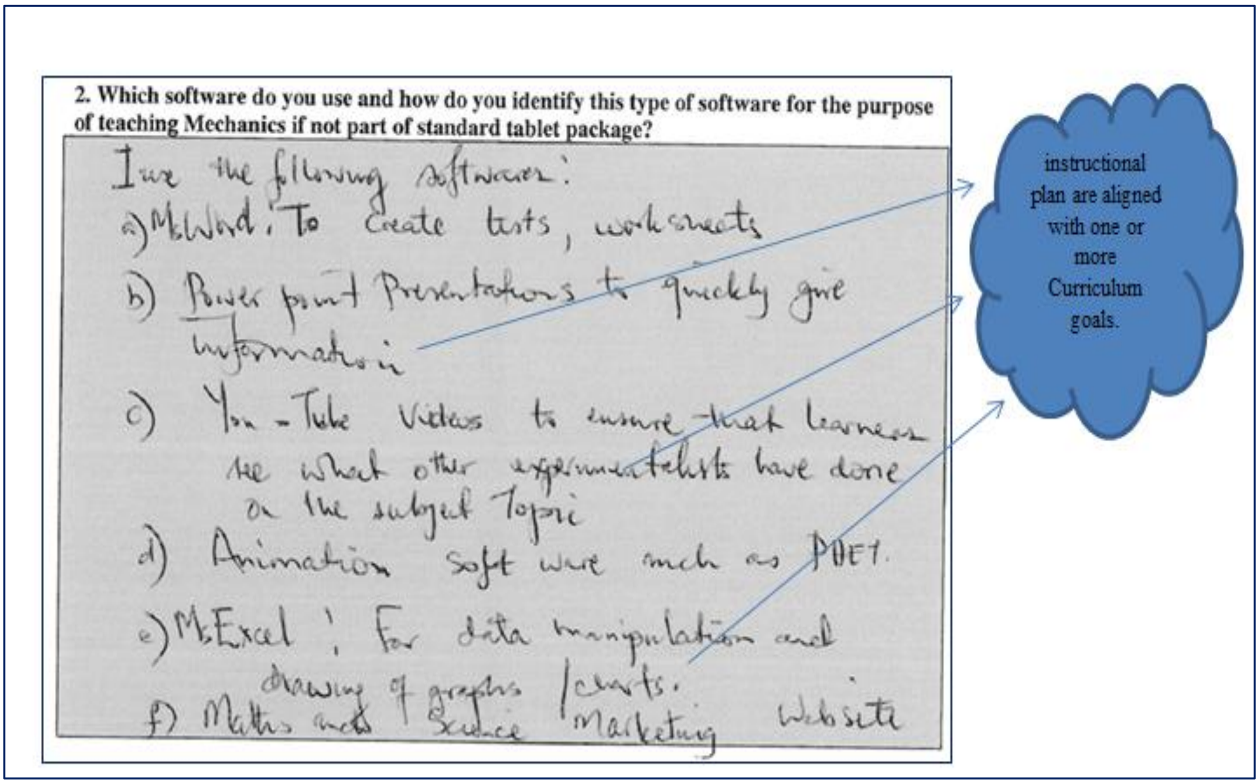


Figure 7: Effective Educator TPACK Reasoning on Technology Selection

Analyzing his responses from the extract of the initial questionnaire above he shows the ability to correctly select technologies that seem to address one or more curriculum goals like giving definitions of gravitational potential energy (*Figure 7: An extract of Content, Concepts and Skills for top Mechanics in Grade 10 Caps document*). He mentions a number of technologies he selects when teaching mechanics. He mentions MS word, PowerPoints, PhET animations and others in a more instructional strategic manner. On observing his lesson for two weeks procedural building knowledge activities like using Excel spreadsheet and proper calculator use were not implemented but other activity types were complemented. On analyzing his response to question 3.2 of a follow-up questionnaire (*Appendix A11*) one observes a similar pattern exhibited in in the extract Figure 7.

In contrast, Mr Ariel was given a score of 2. Analyzing for example, Mr Johns and Mr Ariel based on question 2 of the initial questionnaire, Mr Ariel lists technologies he selects but does not explain how these can be used pedagogically or strategically. According to my scoring this was a scale of 1 score, but on observing his lessons he knew how to use the selected PowerPoint, but other technologies selected were not aligned strongly to the teaching of this Mechanics topic, but applied motor mechanics and perhaps one needs to compare the response Mr John gave for the use of PowerPoint compared to how Mr Ariel response on the same PowerPoint technology. The extract is given below:

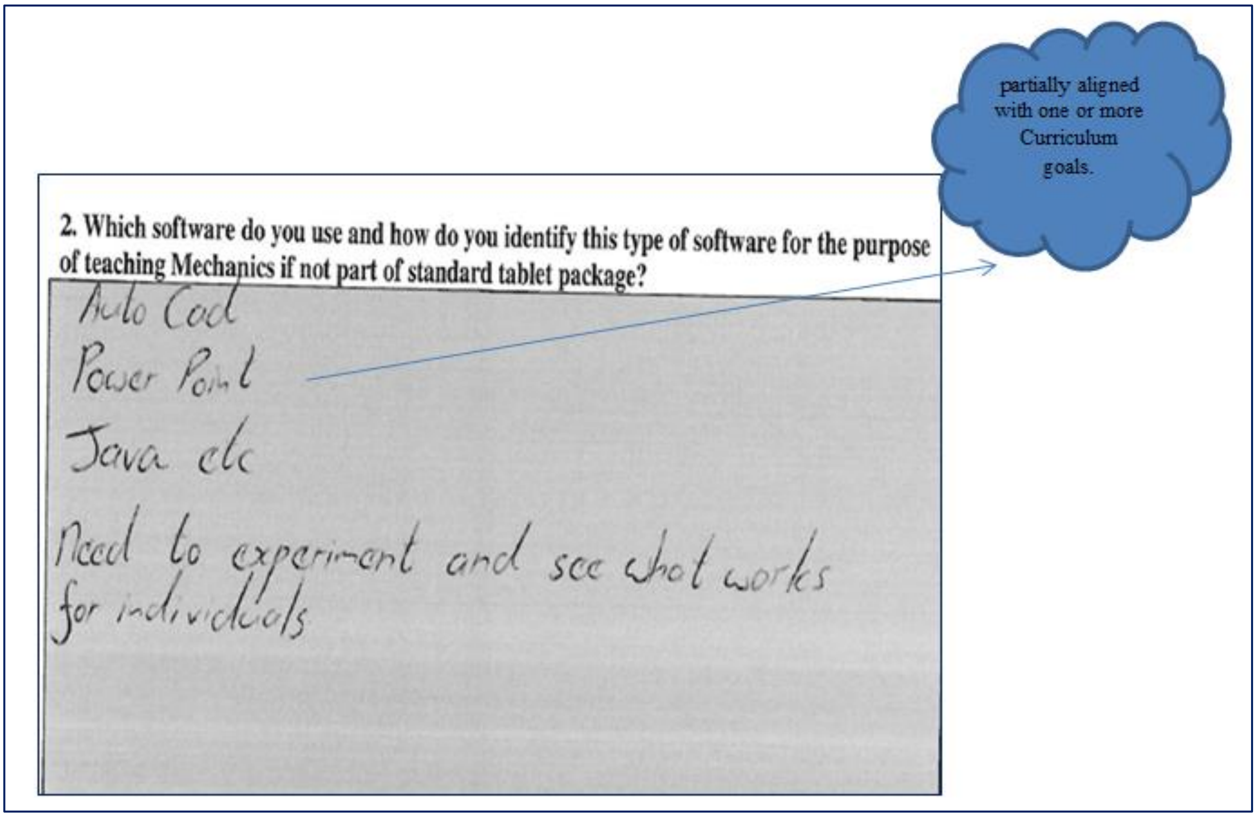


Figure 8: Inadequate Educator TPACK Reasoning on Technology Selection

The scoring process because it was fraught with subjectivities and biases, to minimize the effect and bring fairness, the completed data collection tools were photocopied and in consultation with an independent rater familiar with the marking and the rubric scoring, a final mark was adjudicated upon as a result of consensus. Cases of disagreements in scoring in certain classes of categories of the TPACK rubric occurred. This was resolved by looking at scripts for the participants and the oral presentation from the researcher on what was observed. The independent rater would discuss her views and justify her perceptions of the mark allocated. If the researcher adjudicated that the independent rater was adding value in the assessment, the mark allocated was be agreed by consensus.

In most cases, the researcher allowed the independent rater's views to prevail because I felt my immersion in the study had biases of the researcher. In this sample, only Mr Zuva managed to give responses that were considered as Standard in Class A and this was illustrated in Figure 10 below.

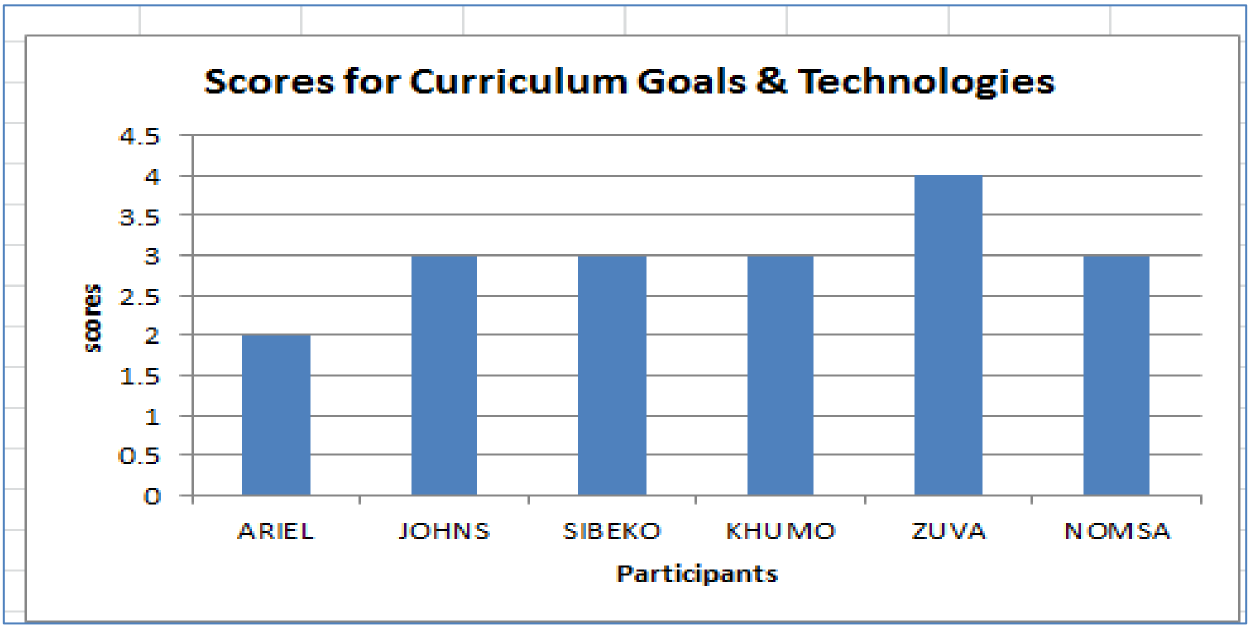


Figure 9: Raw scores for Curriculum Goals and Technologies

The rest of the participants were rated between elementary and developing stage in this classification as they ranged from score 2 to3 as shown in the graph. Those who had scored to the fractions, for the purpose of the TPACK rubric their score were rounded to the nearest decimal if above 5 after the comma. Then if less than 5 after the comma one would maintain the same number before the comma. It was a common mathematical operation or principle of rounding off (But I prefer a figure like the one above showing fractions for interest of noting minute mathematical differences).
This did lead into the analysis of the next category, Instructional Strategies and Technologies.

Instructional Strategies are techniques science educators use in Mechanics to help learners become independent. These become learning strategies when learners can independently select appropriate ones and use them effectively to accomplish tasks or develop skills (Hidden curriculum, 2014).

4.3.2 CLASS B: Instructional Strategies and Technologies (Using technology in teaching/ learning)

The following extracts show the most important ones applied in the teaching of Mechanics *(see appendix A7a-c)*

(i) Conceptual Knowledge Building Activity Types (A7b) - these are strategies educators can use to assist their learners in building science conceptual knowledge in the topic Mechanics, for example:

Table 15: Conceptual Knowledge Building Activity Types A7, A8

Activity Type	*Brief Description (Instructional strategy)*	*Technologies*
Selection Procedures	Students select procedures and accompanying instruments to test hypothesis / or answer questions	Probe ware, digital stirrer, digital timer, digital camera
Sequential Procedures	Students sequence the order of procedures to collect relevant data	Simulation, curriculum software, word processing software

(ii) Knowledge Expression Activity Types (A7c) - these are strategies educators of Physical Sciences may utilize for their learners to express similar understanding of Mechanics content and concepts, at times they use them to inspire their learners to develop and express their own understanding of the topic Mechanics are shown in the extract below:

Table 16: Knowledge Expression Activity Types A7, A8

Activity Type	*Brief Description (Instructional strategy)*	*Technologies*
Develop a concept map	Students participate in or develop graphic organizers, terminology maps	Concept mapping software, interactive whiteboard, drawing software
Debate	Students discuss opposing viewpoints embedded in the science content knowledge laws and principles of Mechanics	Student response system using Bluetooth devices, Video conferencing devices, whiteboard interactive system

(iii) Procedural Knowledge Building Activity Types (A7a) – In Mechanics lessons such as that of Mechanics, constructing conceptual knowledge commonly requires that learners use resources and "process" skills (Millar and Driver, 1987) as they develop scientific knowledge. The table below proffer examples of instructional strategies educators can engage their learners in regards procedures and the use of technologies:

Table 17: Procedural Knowledge Building Activity Types A7, A8

Activity Type	*Brief Description (Instructional strategy)*	*Technologies*
Observations	Students make observations from physical or digital experiences	Video camera with tablets or phones, webcam on computers
Record	Students record observational or previously recorded data in tables, graphs, images and lab notes	Tablets, computers, excel, database usage

Instructional Strategies are therefore used to motivate students, focus attention, and organize information for understanding and to monitor or assess lessons. In this research project, this aspect dealing with Instructional strategies and technologies was measured during the two week observation period as shown in the summary of results in Appendix 6 and Table 13. In a lesson such as Mechanics, it was very easy for an educator to write and state that they simulate experiments and do a lot of activities, but on the analysis, we wanted to see if the pedagogical scientific reasoning and thrust comes out as recorded in literature as depicted in the extracts above (table 4-15 to 4-17).

In this class B of the report project section participant's execution of the strategies and the use of the envisaged technologies was vital from a practical scoring point of view as with lesson planning in-order to make a meaningful score determined by the rubric:

Table 18: Extract of the TPACK rubric scoring instructional Strategies and Technologies Table 12

Class	*Criteria*	4	3	2	1
B **PK, TPK, TCK and PCK**	*Instructional Strategies and Technologies (Using technology in teaching/ learning)*	Technology use optimally supports instructional strategies	Technology use supports instructional strategies	Technology use minimally supports instructional strategies	Technology use does not support instructional strategies

From the initial questionnaire one was able to perceive how the ICT integration would be conducted, and the observation schedule B section (modified science specific activities checklist) depicted in which category and in which activity the educator was often, occasionally or never utilized. The follow-up questionnaire would corroborate with an independent lesson planning if the ICT integrated activities were likely to be involved or not and shed light into categories often utilised than the others. The participants should have shown well mainly in the TPACK activity types because to the greater part of the theoretical construct, one exhibits strong interplay of the following knowledge areas: PK, TPK, and TCK and PCK.

Table 19: Instructional Strategies and Technologies scoring process

	DERIVATION OF TPACK SCORES FOR CLASS B: Instructional Strategies and Technologies			
Participant	Initial Questionnaire	Observation Schedule	Follow-up Questionnaire	Final Score
Mr Ariel	**2**	**2**	**2**	**2**
Mr Johns	**4**	**4**	**4**	**4**
Mr Zuva	**3**	**3**	**3**	**3**
Mr Sibeko	**2**	**2**	**2**	**2**
Ms Nomsa	**3**	**3**	**3**	**3**
Mr Khumo	**3**	**3**	**3**	**3**

Analyzing Mr. Zuva's responses one was able to see his fusion of Instructional Strategies and technologies involved as he reports below that he uses short questions at first to probe learners prior knowledge, and he changes to a video that that takes 5minutes dwelling on a concept. Then he uses PowerPoint to present information on his lessons. He uses a book or worksheet to make learners work. That was assessment stage. Then he finally closes his lesson with a simulation that mimics the concept. This was an example of a teacher whose technology supports his instructional technologies.

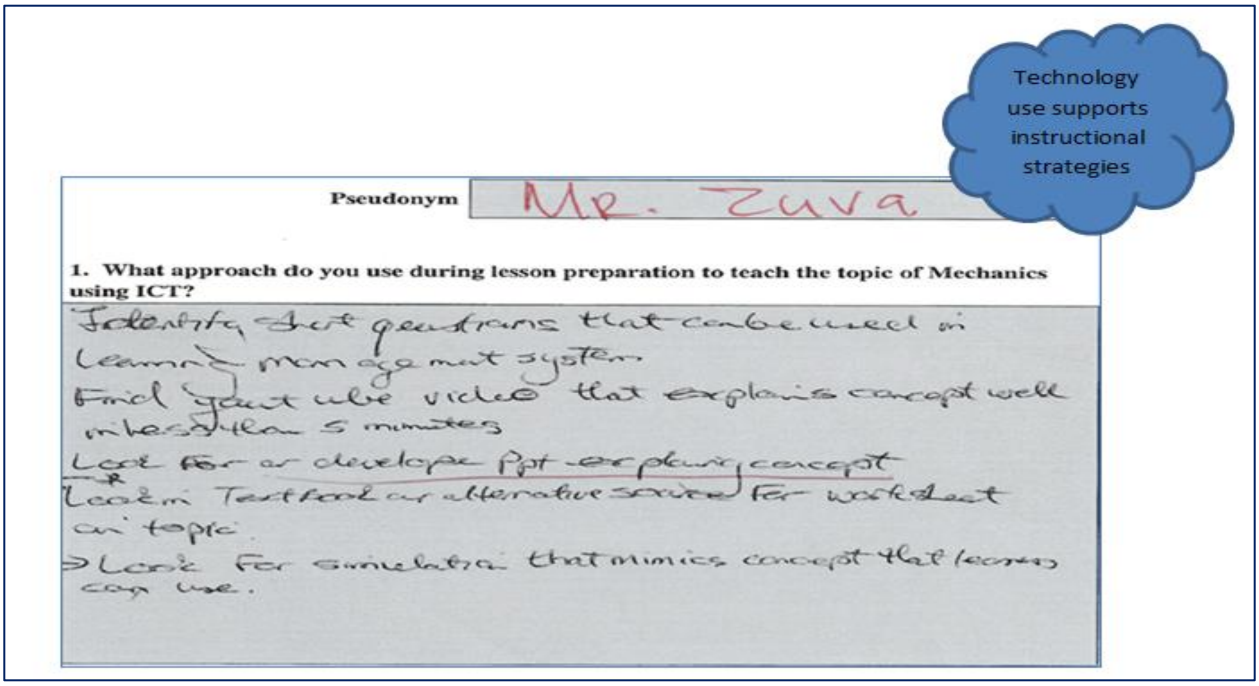
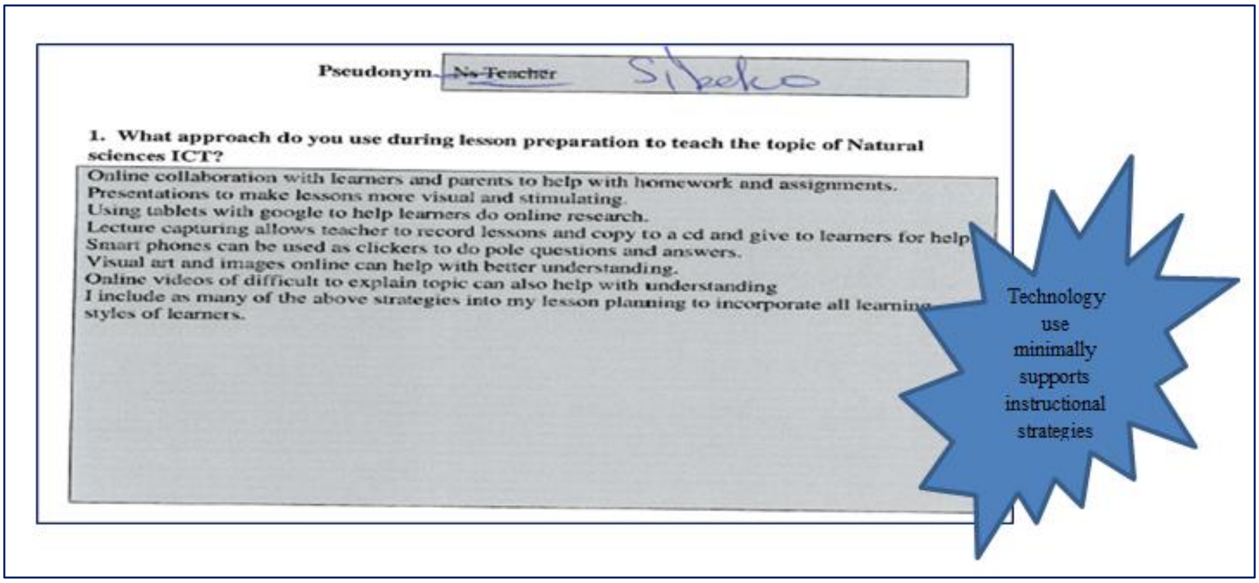


Figure 10: Extract of Instructional Strategies

In contrast, Mr Sibeko has all his strategies clustered together. He does not show how coherent instructional strategies are supported by Technology. Therefore, he was scored with a 2.

InitialQuestionnaireQ1

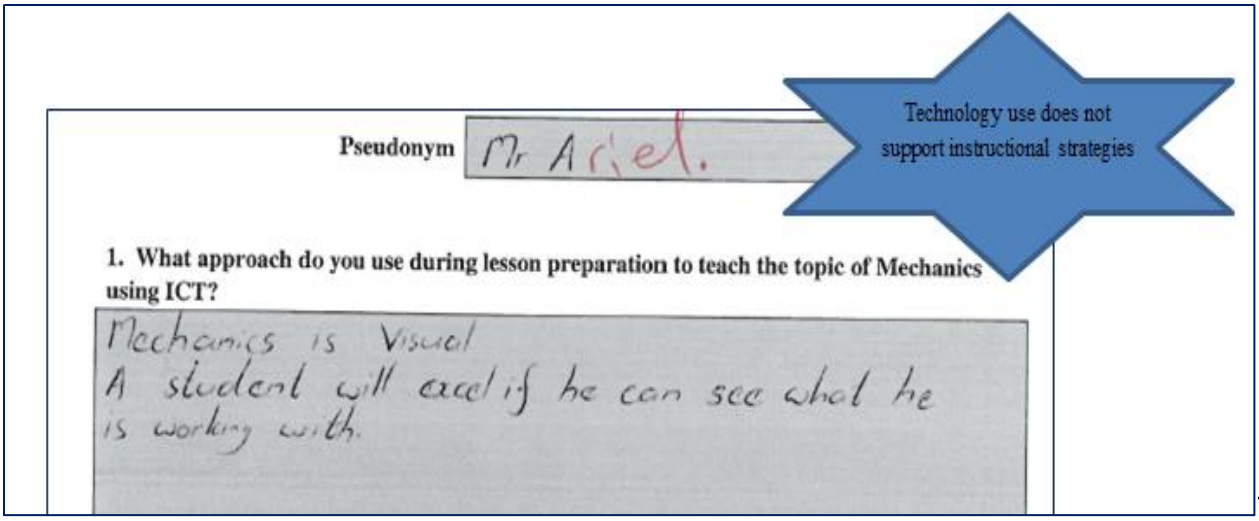

Pseudonym ~~Ns Teacher~~ Sibeko

1. What approach do you use during lesson preparation to teach the topic of Natural sciences ICT?

Online collaboration with learners and parents to help with homework and assignments.
Presentations to make lessons more visual and stimulating.
Using tablets with google to help learners do online research.
Lecture capturing allows teacher to record lessons and copy to a cd and give to learners for help
Smart phones can be used as clickers to do pole questions and answers.
Visual art and images online can help with better understanding.
Online videos of difficult to explain topic can also help with understanding
I include as many of the above strategies into my lesson planning to incorporate all learning styles of learners.

Figure 11: Extract of "clustered instructional strategies

Whilst Mr Ariel was self- taught, he does not expand on his strategies and on observation one notices this type of erratic planning on his part. He was scored with a 2. Mr Johns list (scored 4) in a live observable lesson it was implementable as he described in the plan and it differs from Mr Sibeko's list (scored 2) because in the actual observed lessons it could not be methodically implemented and both for Sibeko and Ariel end up saving no pedagogical purpose.


Pseudonym Mr Ariel.

1. What approach do you use during lesson preparation to teach the topic of Mechanics using ICT?

Mechanics is Visual
A student will excel if he can see what he is working with.

Figure 12: Ineffective Type of ICT Instructional Strategy

John explains very well his strategies and he was different in that he has his work planned in advance. He uses his past experience to execute his strategies with a well-choreographed dexterity. He was scored with a 4 *(see Table 4-19)*

But it was at this Class B where most of the educators fail to demonstrate the effectiveness or to apply instructional strategies as expected in teaching and learning of Mechanics *(suggested in the appendix A7a-c, App 8 and results Table 11)*

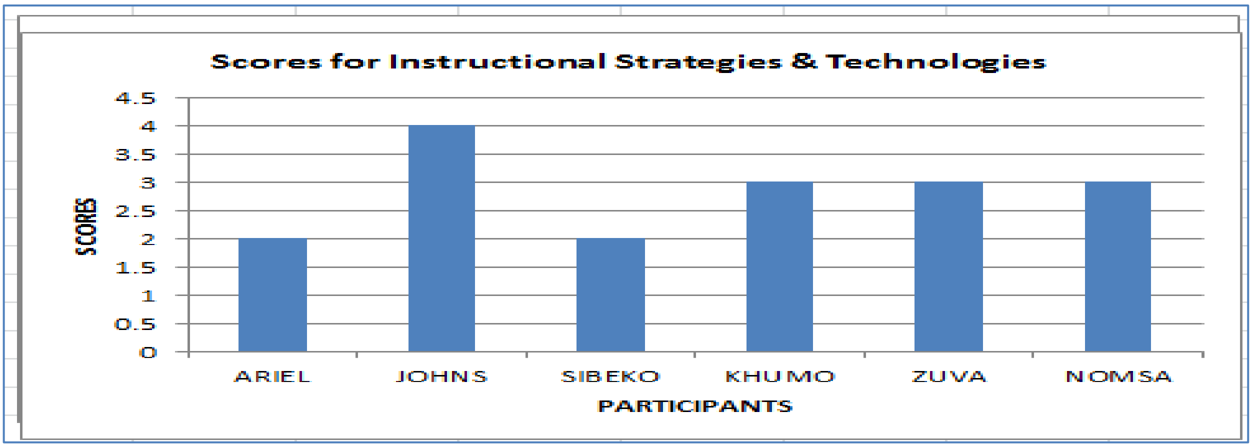


Figure 13: Teachers' TPACK scores for Instructional Strategies and Technologies

4.3.3 CLASS C: Technology Selection(s) (Compatibility with curriculum goals and instructional strategies)

According to the National Research Council (NRC, 1999), technology ought to be understood in terms of how it can assist or impede the achievement of learning and teaching goals. In this class of measure, educators ought to have the ability to know the type of hardware to use in a particular lesson according to the science activities described in tables 15 to 17 (Appendix A7a-c and A8).

The scoring again depended on the three instruments: Initial Questionnaire, Observation Schedules and Follow-up Questionnaire. In this case, during observations participants had to show creativity required not only to select a technology but one that was strategically inclined to achieve a successful instruction for learners. It went beyond giving a definition only. But if a gravitational acceleration was being taught, I needed to see a building activity type or a procedural activity with the use of technology (be it calculators, spreadsheets on excel, simulations or film editor on smartphones).

In one situation, Mr Zuva decided to use the edutrade desk (Observation A (notes) on Appendix 5 and A6). This was a big desk, which allows teachers and learners to do procedural experiments from how to set the apparatus until carrying out the experiment. In the other scenario I observed Mr Zuva opted to use the interactive smart board where textbooks and worksheets are displayed on one side and another partially used for explanations which can be saved and replayed more after the lessons.

In my notes I recorded that Mr Khumo (Observation A (notes) on Appendix A5 and A6) had an interactive smart TV that also allowed him to work with a board on one side and a past exam on the other. Hence, if one observes Mr Khumo and Mr Zuva had a similar scoring because I adjudged that both techniques when used properly produce a balanced ICT integration classwork for Mechanics.

Table 20: Technology Selection(s) (Compatibility with curriculum goals and instructional strategies) scoring process

	DERIVATION OF TPACK SCORES FOR CLASS C: Technology Selection(s) (Compatibility with curriculum goals and instructional strategies)			
Participant	Initial Questionnaire	Observation Schedule	Follow-up Questionnaire	Final Score
Mr Ariel	**2**	**2**	**2**	**2**
Mr Johns	**3**	**3**	**3**	**3**
Mr Zuva	**4**	**4**	**4**	**4**
Mr Sibeko	**3**	**3**	**3**	**3**
Ms Nomsa	**3**	**3**	**3/2**	**3**
Mr Khumo	**4**	**4**	**4**	**4**

Mr Zuva's lessons showed a lot of input in terms of strategy in terms of actual observations. What he describes that uses, he actually does and these technologies he has mastered their actual use like the ones he mentions below:

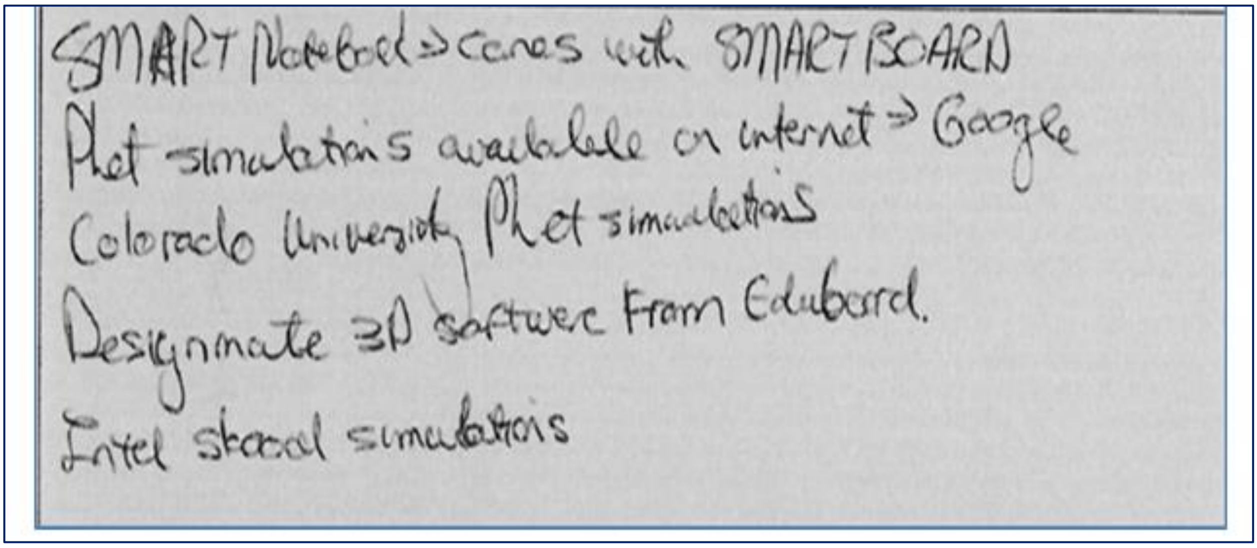

SMART Notebook => Comes with SMART BOARD
Phet simulations available on internet => Google
Colorado University Phet simulations
Designmate 3D software From Eduboard.
Intel school simulations

Figure 14: Extract of Mr Zuva show-cases selected technologies

Technology selection involves knowledge of the software sources by the educator. In most cases there are several service providers like Mathsandscience Marketing, Sangari South Africa, Khan Academy and others. The educator has to research on what the best materials are out there and knowledge of the requirements for such programs. Other materials under technology selection are recommended by subject advisors and specialists, but still the onus was on the educator to assess the best strategy and implementation plan for a particular group of students to be taught and the relevance and accuracy of the content. According to Ms Nomsa most of her technology selection was mainly from the service provider Sangari South Africa. Her selection was based on the strength that this was approved by the department of education:

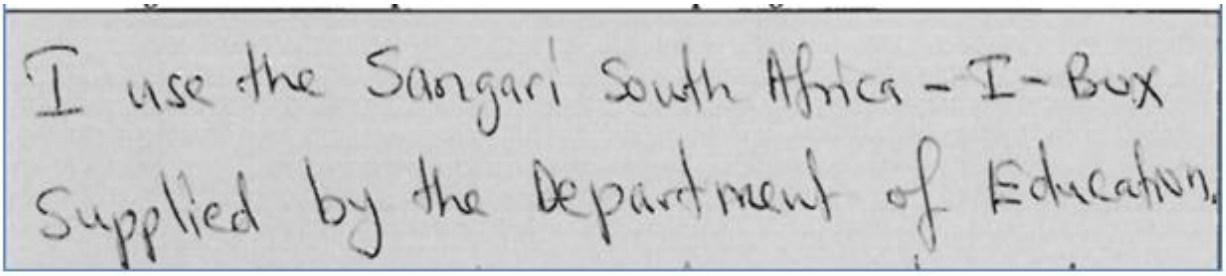

I use the Sangari South Africa - I-Box
Supplied by the Department of Education,

Figure 15: monolithic selection of technologies

This was different from Mr Zuva who turns to a variety of sources own his own to accomplish teaching goals. Scoring the two did show that Mr Zuva has an in-depth knowledge in technology selection as compared to Ms Nomsa. This evaluation was done consistently for all the teachers by analyzing the source and how they make a coherent lesson and the results of their scores are as below:

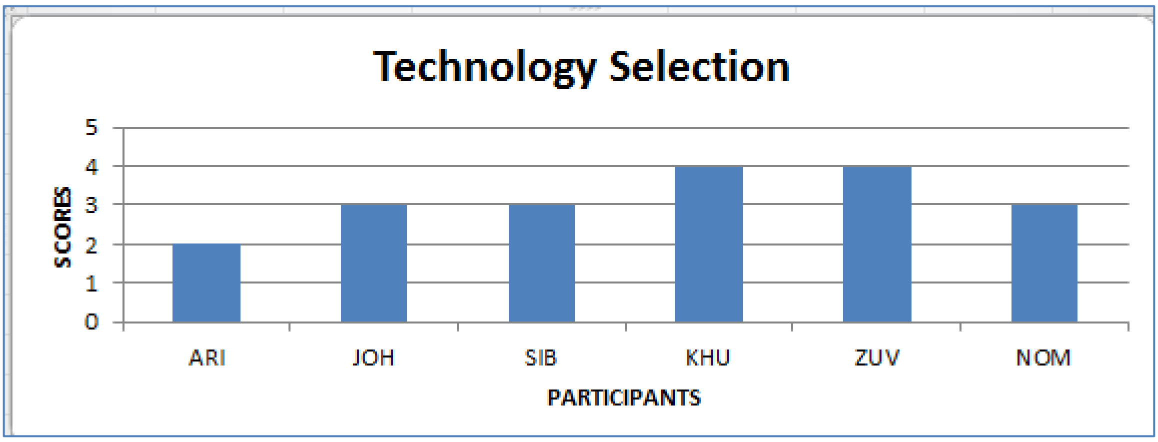


Figure 16: Technology Selection Scores

Koehler and Mishra (2009) posited that educators must understand the manner in which technology and content influence and constrain one another. This was viewed in terms of how good technology was selected to fulfill curriculum goals and one's instructional strategies as shown above.

4.3.4 CLASS D: Fit (Content, pedagogy and technology together).

In class D a complete evaluation of the extent of fusion of Content, Pedagogy and Technology was analyzed and this is called Fit for the purposes of this research project. It must be noted that CLASS D was an interesting category in that it involves a comprehensive understanding of the trade of teaching and learning Mechanics. Furthermore, the CAPS arrangement was in the form of topics *(see appendix A27).* The mechanics are the topic of research in this project. Knowledge of measuring topic specific nature of concepts and principles involved in the subject Physical Sciences was very paramount because it gives insight into the content specifically and pedagogy relationship. This was called topic specific pedagogical content knowledge (TSPCK- Mavhunga, 2012). The background to topic specific measurements include the aspects of TSPCK attributes teachers of Physical Sciences ought to possess which are considered very important in evaluating the fusion of specific content and pedagogy (**before the Technology aspect was added on**) and these are: *learner prior knowledge, conceptual teaching strategies, representations/analogies/models, understanding what makes topic difficult easy or difficult to understand and curricular saliency* (Mavhunga and Rollnick, 2013).

During the two weeks class observation, I would ascertain the accuracy of the Mechanics specific content being taught (I checked the accuracy of the content in the lesson plans and made notes on how it was being delivered by the participant). Then I made notes on the correctness concerning the various attributes required for topic specific teaching and learning Mechanics showed in italics above (TSPCK- Mavhunga, 2013).

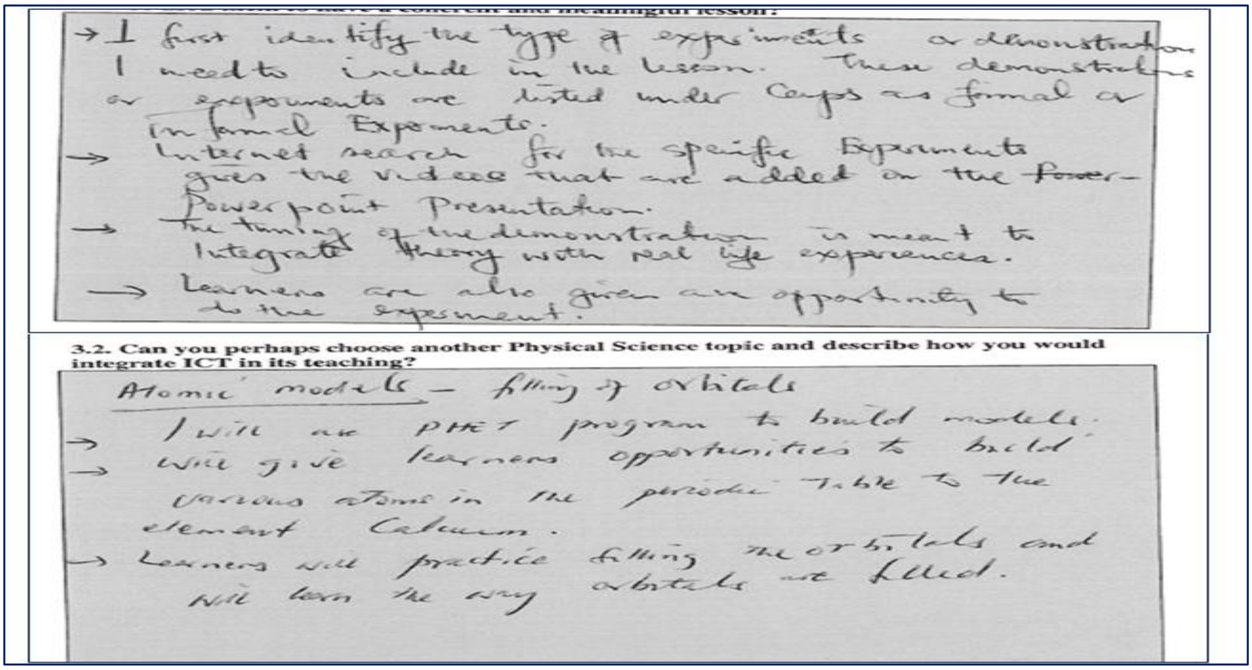
In summary, I can say I did Mechanics content evaluation, followed by quick assessment of the fusion of topic specific pedagogy on Mechanics teaching and finally this then allowed me to score participants' performance when technology was added to these two aspects - this then allowed this researcher to make an assessment of the technology component thereby completing the assessment of a Fit (content, pedagogy and technology together).

The main instruments used were the Observation Schedule (Observation A – which allowed notes to be recorded on content, pedagogical skills and technology applied to the Mechanics lesson). The follow-up questionnaire was used as a complementary tool used in scoring because it gave an insight into an independent ICT integration planning. The results obtained are below:

Table 21: Fit (Content, pedagogy and technology together) scoring process A5, A7 and A11

	DERIVATION OF TPACK SCORES FOR CLASS D: Fit (Content, pedagogy and technology together).			
Participant		Observation Schedule	Follow-up Questionnaire	Final Score
Mr Ariel		**2**	**2/1**	**2**
Mr Johns		**4**	**4/3**	**4**
Mr Zuva		**3**	**3**	**3**
Mr Sibeko		**2**	**2/3**	**2**
Ms Nomsa		**3**	**3/2**	**3**
Mr Khumo		**3**	**3/2**	**3**

Mr Johns Response Schedule shows in the first extract how he did make a coherent Mechanics lesson by properly describing what he needs to do for the content (he was teaching gravitational principle), the well-organized pedagogical strategies (use of experiments, simulations, demonstrations) and the relevant applicable technologies.


→ I first identify the type of experiments or demonstration I need to include in the lesson. These demonstrations or experiments are listed under Caps as formal or informal Experiments.
→ Internet search for the specific Experiments gives the videos that are added on the Power-Powerpoint Presentation.
→ The timing of the demonstration is meant to integrate theory with real life experiences.
→ Learners are also given an opportunity to do the experiment.

3.2. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

Atomic models – filling of orbitals
→ I will use PHET program to build models.
→ Will give learners opportunities to build various atoms in the periodic Table to the element Calcium.
→ Learners will practice filling the orbitals and will learn the way orbitals are filled.

Figure 17: Mr John's FIT assessment records: Initial questionnaire Q4 and Follow-questionnaire Q 3.2

The second extract Mr Johns takes an example of a topic in CAPS, Atomic Models. He articulates the content he wants the learners to learn (filling of orbitals). He explains the pedagogical strategies he was going to use (PhET program for simulations and the periodic table) and outlines in each case the technologies to be used.

3.2. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

The Mole Concept

1. Take Sangari Caps Aligned Power Points on Mole Concept
2. Take Maths Science Marketing Aligned Power Points on Mole Concept.
3. Arrange them in the order of how I want to teach the children/learners according to the Caps Interpretation

I am a Physical Science trained Educator, I have the knowledge of the Content and therefore I have the ability to arrange the Lesson accordingly.
I select Exercise that fit my time-table
I select Phet Animations I want to use for demonstrations and the ones I want learners to review until the Concepts are understood.
Then Arrange Practicals when suitable.

Figure 18: Ms Nomsa Independent confirmatory ICT integrated lesson plans: Q3.2 Follow-up Questionnaire and Q2 Initial Questionnaire

Ms Nomsa descriptions compared to Mr Johns does not show how she “selects” as the Sangari Power Points (Sangari is an educational software and hardware developer and supplier for GDE) came arranged already by the service provider. Even during the class observation one noted that she relied heavily on using these materials from the service provider. She does not give enough insight on how her ICT integration knowledge goes about.

In the second extract, her content depended solely again from that which was provided by the service provider. She also does not qualify how she arranges the lesson for ICT integration. During observations one notices that she heavily uses PowerPoints without resorting to other strategies because the service providers have less of these variations as compared to one who does on his own like Mr Johns.

Thus, Ms Nomsa was awarded a 2 on Fit evaluation.

In class D a complete evaluation of the extent of fusion of content, pedagogy and technology was analyzed by the rater in conjunction with the researcher, by going through all the instruments and objectively (and subjectively) scored as far as they could then describe proffered by the educators that depicted FIT and compared their scoring.
In most instances the researcher had to narrate to the rater as to what was observed in-situ. Furthermore, the initial (structured) questionnaire schedule dealt with most aspects of FIT and the question 3.2 on the follow-up questionnaire deal with FIT but using any other topic of Mechanics. This was done to ascertain if indeed the educator had knowledge of fusing content, pedagogy and technology beyond the agreed topic.

Therefore the concept of Fit incorporating content, pedagogy and technology (CK, PK and TK?) together was described: Koehler and Mishra (2008), posited that TPACK requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Pp. 17-18).
We had scoring disagreements on three educators and we decided to take an average score as a representative score of each educator in classification of class D.

Their scores (rest of scoring see Figure 19 shown below and are the lowest scores of all Classes in TPACK Rubric:

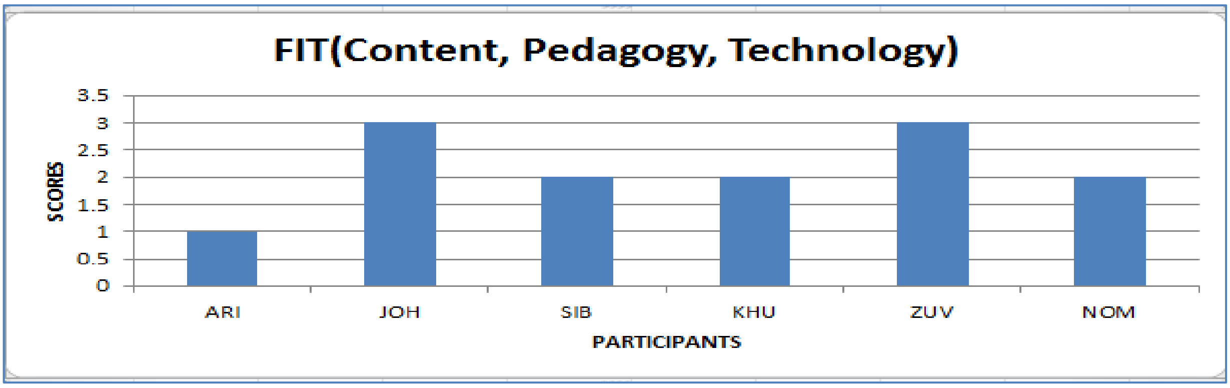


Figure 19: Fit incorporating content, pedagogy and technology together – Scores

To make a meaning of all the traits measured of the theoretical construct TPACK an analytical tool was then sort that did give a strong valid and credible argument to answer the research question number 1 which deals with the extent of effectiveness of a new tool of teaching - ICT. I settled for the Rasch Statistical Model and the reason are proffered below:

4.4 The Rasch Statistical Model.

It is recognized in Social science studies, like educational research that the trouble to make measures is founded on the tentative nature of the qualities of individuals and occurrences to be quantified as far as examples of attitudes of educators towards ICTs, beliefs about learning using ICTs, and so forth. These are concealed traits not directly visible or physically apparent Phillipson, Subramaniam, Tomkinson, Walker and Young (2011). Rasch Statistical Model has permitted a high degree of measurement of concealed qualities in individuals by generating a system of observations that can be well-arranged and then these did enable comparison of the capabilities of different individuals. The accomplishment or non-completion of data collection tools such as used in this project provides the observational statistics required to make determine a measure of such qualities... This data was gathered as scores for individuals and for classifications to show the quantity of the data in the instruments completed by each individual and also the quantity of individuals concluding each instrument. The Rasch Statistical Model arranges the statistics, by individual ability (number of tasks completed) and assignment difficulty. Hence Bond and Fox (2001, p. xix) stated that the theory was constructed on the basic notion that all individuals are more *probable* to answer easy items appropriately than problematic items, and all items are more likely to be passed by individuals of higher ability than by those of low capability. These measures are invariant because although they are sensitive to differing levels of the quality in different individuals, the gauge against which the individuals are measured does not differ. This permits valuations between groups and persons to be equaled with a high degree of certainty.

4.4.1 The Rasch statistical model functioning with the TPACK Rubric

The **TPACK rubric** was used to produce aggregated scores from data collection instruments. The collated results of scores for each trait or class on the rubric and the corresponding persons or participants were obtained.

The data obtained above firstly permitted me to work with a small sample of educators (as participants). A small sample because it was a small representation of approximately 2 200 schools that were involved in the ICT Gauteng schools programme. The sample encompassed major categories of schools involved although not exhaustive. The participants were a small group known to the researcher to be involved in the integration of lessons in Mechanics but also not the only ones from the 2 200 High schools. But for the purpose of study the six participants and the contexts they operate from would offer approximate unchanging item limits and fit the data to the construct, and not vice versa (Kim and Barton, 2010). Although a small sample (as alluded above) was used for this research project Rasch MINISTEP allowed an in-depth assessment of the quality of classes on the **TPACK rubric** scale as was be shown in the chapters following. The assessment in-turn allowed me to have a better comprehension of the TPACK construct, the fundamental trait whose extent in educators was being assessed in this particular project.

Secondly, the Rasch analysis allowed me to assess in a single study not only the quality of classifications, but the extent of TPACK knowledge of the participants in this project. This was possible because the statistical model is able to place participant educators, according to their level of ability alongside TPACK classifications, which are ordered according to their difficulty (Bond and Fox, 2007). This permitted me to understand how classifications on the TPACK rubric match the selected sample.

Lastly, the Rasch analysis provided statistics both for the classifications and person reliability and classification characteristics, thereby allowing me to determine the reliability of the TPACK rubric classifications of the construct.

4.5 The Raw Scores from TPACK RUBRIC Classifications

The Raw Scores are the **TPACK rubric** aggregated scores from data collection instruments which have been scored by me as the researcher (FM) and an independent Rater (the independent specialist conversant with the study).

The table below shows how the scoring process took place. The table shows that there are 5 instances of disagreement between me and the rater (4 shaded in blue and 1 in yellow) - Fit- in blue (Ariel, John, Khumo and Nomsa) and Technology Selection in yellow (Nomsa). This was compared to a backdrop of a total of 19 agreed instances (indicated in green). ***The scoring resolution was explained in 4.3.1.***

Figure 20: The Scoring Process

	Curriculum Goals & Technologies		Instructional Strategies & Technologies		Technology Selection(s)		Fit(Content, Pedagogy & Technology together)	
PARTICIPANTS	*FM*	*RATER*	*FM*	*RATER*	*FM*	*RATER*	*FM*	*RATER*
ARIEL	2	2	2	2	2	2	2	1
JOHN	3	3	4	4	3	3	4	3
SIBEKO	3	3	2	2	3	3	2	2
KHUMO	3	3	3	3	4	4	3	2
ZUVA	4	4	3	3	4	4	3	3
NOMSA	3	3	3	3	2	3	3	2

The total percentage agreement was approximately **79%, which** was very good, indicative of the reliability of the scoring of the tool.

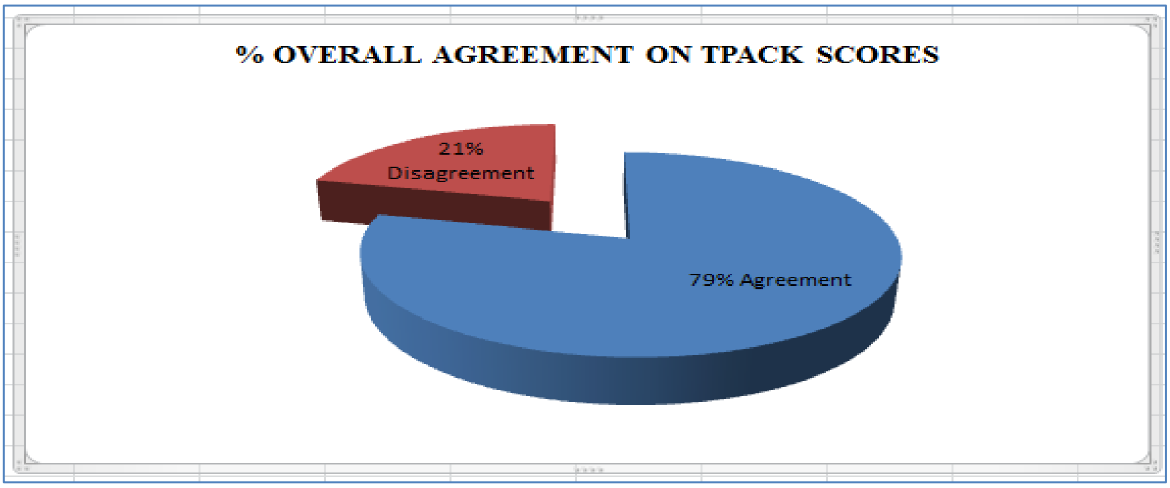


Figure 21: Percentage agreement scores

TPACK rubric aggregated scores obtained by consensus are now shown below and become known as the TPACK Raw Scores:

Figure 22: The TPACK Raw Scores for all Participants (consensus scores)

	TPACK				
PARTICIPANTS	Curriculum Goals & Technologies	Instructional Strategies & Technologies	Technology Selection(s)	Fit(Content, Pedagogy & Technology together)	SCORE
ARIEL	2	2	2	1	7
JOHN	3	4	3	3	13
SIBEKO	3	2	3	2	10
KHUMO	3	3	4	2	12
ZUVA	4	3	4	3	14
NOMSA	3	3	3	2	11

The scoring resolution was explained in 4.3.1.

Observing TPACK categories vis-a-vis educator showing, participants gave a poor quality showing in their responses in the fundamental class of a Fit (content, pedagogy and technology combined together) where a participant got a criterion of 1 (inadequacy) and majority 2 (elementary) John and Zuva got 3. This was followed by Instructional strategies and Technologies where participants failed to articulate and practically demonstrate this aspect satisfactorily 3 people obtained a score of 3 – support except for the Mr John score of 4 – optimal support. But the participants showed a good performance in the Technology Selection(s) in which educators were able to choose a number of hardware's and software's for pedagogical purposes, scoring maximum of 4 (Standard level) and 3 (Developing) coupled by linking them to the category of Curriculum Goals and Technologies where only one educator got 2 (elementary level) criterion.

The calculation of average scores for TPACK became imperative because the construct TPACK was not a sum of the individual TPACK rubric classifications as components but their collective influence and interaction into each other. Therefore the table below shows the average TPACK means scores that could be used with the TPACK rubric whose criteria of measurement are whole numbers not fractions of traits.

Figure 4-23: Table mean scores

TPACK MEAN SCORES			
PARTICIPANTS	TPACK SCORE	MEAN(AVERAGE)	OVERALL
ARIEL	7	1.75	2
JOHN	13	3.25	3
SIBEKO	10	2.50	3
KHUMO	12	3.00	3
ZUVA	14	3.50	4
NOMSA	11	2.75	3
SAMPLE AVERGE			3

The physical science educators using ICTs displayed a Developing TPACK (rating of 3).

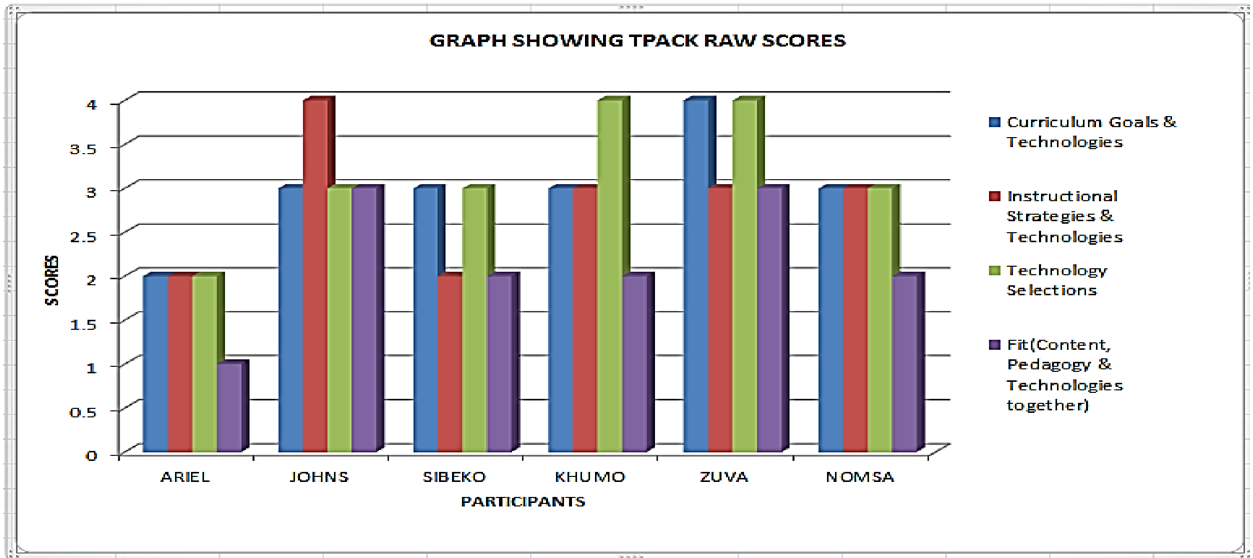


Figure 24: Graph 4: Showing differential representation of TPACK classes and raw scores for each Classification

The results in table 4 the TPACK Raw Scores for all Participants (consensus scores) and the subsequent Graph 4 showing a differential representation of TPACK RAW SCORES do not give much information on the vital issues, for example, of the validity of the tool, the reliability of items and persons and item characteristics that allows comparison to explain the fundamentals of the extent of the underlying construct or trait- in this case TPACK. The Rasch model sums up completely a person's standing on a human trait like TPACK in this project by providing estimates of internal consistency and linear comparisons and hence the need therefore to convert this obtained data to Rasch scores.

4.6 The TPACK Raw Scores Converted To Rasch Scores

The TPACK rubric based results now called the Raw Scores were put to the Rasch measurement and the associated computer program called the MINISTEP (Winsteps) Rasch Version 3.91.2. The MINISTEP program for comparative purposes "(1) create linear, unidimensional measures; (2) entail that statistics must fit the measurement theory; (3) create scale-free individual measures; (4) produce sample-free item complications; (5) determine average errors; (6) approximate individual measures and item difficulties on the same linear scale in standard units (logits); and (7) determine that the counting system is being used rationally and reliably (Phillipson, Subramaniam, Tomkinson, Walker and Young, 2011, page xi). The Rasch statistical theory involves converting the raw marks gotten from the rubric as ordinal figures, into statistical measures that are situated on a direct scale with equal intervals (Bond and Fox, 2001). This transformation is called 'standardized in Rasch'.

TABLE 17.1 TPACK MF ZOU031WS.TXT Mar 24 2016 12:42
INPUT: 6 Person 4 Item REPORTED: 6 Person 4 Item 4 CATS MINISTEP 3.91.2

Person: REAL SEP.: 2.51 REL.: .86 ... Item: REAL SEP.: 2.39 REL.: .85

Person STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
5	14	4	80.41	12.65	.47	-.8	.35	-.6	.75	.68	100.0	77.1	ZUVA
2	13	4	66.70	11.16	1.83	1.6	2.13	1.7	.10	.62	50.0	70.7	JOHN
4	12	4	53.65	12.30	.78	-.2	.57	-.1	.92	.68	75.0	75.3	KHUMO
6	11	4	25.65	24.06	.03	-1.0	.03	-1.0	.96	.88	100.0	95.5	NOMSA
3	10	4	-4.32	13.18	.47	-.8	.32	-.2	.75	.66	100.0	78.8	SIBEKO
1	7	4	-68.29	27.99	.04	-.9	.03	-1.0	.96	.89	100.0	96.7	ARIEL
MEAN	11.2	4.0	25.63	16.89	.60	-.4	.57	-.2			87.5	82.3	
P.SD	2.3	.0	50.32	6.59	.61	.9	.72	.9			19.1	10.1	

Umean = 0 (standard environment for fair comparison averages for all traits being measured)

Figure 25: Statistical measures located on a linear scale with equal intervals

An explanation of some of the headings used for the purposes of understanding the "Standardization of data in Rasch" – others were further explained in context.

♦ *Entry Number:* The number allocated to the participant in the research project, e.g. Zuva was # 5.

♦ *Total Score:* These are the raw scores obtained by each participant from the **TPACK rubric** scores.

♦ *Total Count:* Is the number of items the participants were being assessed, CLASS A, B, and C and D.

♦ *Measure:* linear unidimensional scale that allows a measure of an observed hierarchy with respect to the person's capacity of answering and the order of item difficulty.

♦ *INFIT and OUTFIT:* were explained in context

♦ *Person Rel:* Person Reliability were be explained in context

♦ *Item Rel:* Item Reliability were also be explained in context

♦ *Person:* Is the pseudonym or abbreviation of the name of the participant e.g. SIB for Sibeko

4.7 Analysis of the Validity and Reliability Statistics of the Rasch

4.7.1 Fit statistics as evidence of validity

Fit statistics (*different from the Fit on TPACK rubric*) offer an amount of variance of which responses from tools follow a rational configuration and also provide hints of the measures of rationality for a particular participant (Green and Fantom, 2002). In other words fit statistics empower us to observe how well the data fits the theory and try to shed light on the question of whether the tools and instruments used in the project determines what they claim to measure. That is the principle of what validity responses to. Fit is obtained from the variance between the perceived and the mathematical possibility scores generated by Rasch which are called Residuals. The residuals are divided into two types, namely INFIT (determined by the space between the individual position and classification difficulty on a linear scale) and OUTFIT (an unscaled measure) (Green and Fanton, 2002). The INFIT is thoughtful to uneven answers to on-target items, whereas the OUTFIT is mindful to unforeseen answers off-target items (de Bruno, 2011). INFIT and OUTFIT indicators are known as both average squares (MNSQ) and Regular Z values (ZSTD). MNSQ is the chi-squared indicator divided by its autonomy with the expected value approximating to 1, 0 and the range from

0 to limitlessness (Bond and Fox, 2007). Therefore a ***MNSQ of 1.0 and a Z value of 0 designate a good FIT.***

In this research project it can be observed that all other participant's fall within a perfect fit value thereby fitting the model but participant entry number 2, Mr Johns has MNSQ value infit 1.83 and outfit 2.3 respectively, values over 1.0 of a perfect fit. This discrepancy can be located within the unexpected response measures below:

```
TABLE 6.6 TPACK MF                              ZOU273WS.TXT  Mar 24 2016 12:47
INPUT: 6 Person  4 Item  REPORTED: 6 Person  4 Item  4 CATS     MINISTEP 3.91.2
--------------------------------------------------------------------------------

MOST UNEXPECTED RESPONSES

------------------------------------------------------------------------------------------------------------
| DATA |OBSERVED|EXPECTED|RESIDUAL|ST. RES.|MEASDIFF| Item  | Person | Item                      | Person |
|------+--------+--------+--------+--------+--------+-------+--------+---------------------------+--------|
|    4 |      4 |   3.17 |    .83 |   2.21 |  72.43 |     2 |      2 | InstructStrategy & Tech   | JOHN   |
|    3 |      3 |   3.72 |   -.72 |  -1.59 |  97.58 |     3 |      2 | Tech Selection            | JOHN   |
|    4 |      4 |   3.41 |    .59 |   1.21 |  84.53 |     3 |      4 | Tech Selection            | KHUMO  |
|    3 |      3 |   3.44 |   -.44 |   -.89 |  86.14 |     2 |      5 | InstructStrategy & Tech   | ZUVA   |
|    2 |      2 |   2.42 |   -.42 |   -.85 |   1.41 |     2 |      3 | InstructStrategy & Tech   | SIBEKO |
|    2 |      2 |   2.37 |   -.37 |   -.77 |   -.73 |     4 |      4 | Content Pedagogy & Tech   | KHUMO  |
|    3 |      3 |   2.69 |    .31 |    .68 |  12.32 |     4 |      2 | Content Pedagogy & Tech   | JOHN   |
|    3 |      3 |   2.90 |    .10 |    .33 |  26.03 |     4 |      5 | Content Pedagogy & Tech   | ZUVA   |
|    3 |      3 |   2.94 |    .06 |    .24 |  31.38 |     2 |      6 | InstructStrategy & Tech   | NOMSA  |
|    2 |      2 |   2.03 |   -.03 |   -.18 | -28.73 |     4 |      6 | Content Pedagogy & Tech   | NOMSA  |
------------------------------------------------------------------------------------------------------------
```

Figure 26: Most Unexpected Responses

The statistics of most unexpected responses shows that Mr Johns gave the most unexpected responses than all participants combined in the area of instructional strategies and technology selection. This might be true for one who claims to be untrained in ICT. He was also the 4th in content, pedagogy and technology classification to offer most unbalanced / unanticipated responses both on target and off target items (*Linacre, 2015*). This might be attributed to him being the most trained participant in the subject Mechanics (*see Appendix A*).

```
TABLE 10.5 TPACK MF                              ZOU273WS.TXT  Mar 24 2016 12:47
INPUT: 6 Person  4 Item  REPORTED: 6 Person  4 Item  4 CATS     MINISTEP 3.91.2
-------------------------------------------------------------------------------

MOST UNEXPECTED RESPONSES
Item                         MEASURE   |Person
                                       |2
                                   high-
2 InstructStrategy & Tech      -5.73 2|4
                                       |-low
                                       |2
```

Figure 27: Class with most unexpected responses

The table below shows the measurements of classifications of the TPACK rubric:

```
TABLE 13.1 TPACK MF                              ZOU273WS.TXT  Mar 24 2016 12:47
INPUT: 6 Person  4 Item  REPORTED: 6 Person  4 Item  4 CATS      MINISTEP 3.91.2
--------------------------------------------------------------------------------
Person: REAL SEP.: 2.51  REL.: .86 ... Item: REAL SEP.: 2.39  REL.: .85

         Item STATISTICS:  MEASURE ORDER

-----------------------------------------------------------------------------------------------------------
|ENTRY   TOTAL  TOTAL           MODEL|   INFIT  |  OUTFIT  |PTMEASUR-AL|EXACT MATCH|                      |
|NUMBER  SCORE  COUNT  MEASURE  S.E. |MNSQ  ZSTD|MNSQ  ZSTD|CORR.  EXP.| OBS%  EXP%| Item                 |
|------------------------------------+----------+----------+-----------+-----------+----------------------|
|     4     13      6    54.38  12.32| .38  -1.0| .21   -.4|  .91   .86|100.0  84.8| Content Pedagogy & Tech|
|     2     17      6    -5.73  11.21|1.35    .8|1.09    .5|  .80   .80| 83.3  79.9| InstructStrategy & Tech|
|     1     18      6   -17.76  10.99| .42  -1.2| .27   -.3|  .85   .82|100.0  80.4| Curriculum Goals & Tech|
|     3     19      6   -30.89  12.11|1.30    .6| .70    .2|  .85   .87| 66.7  84.2| Tech Selection       |
|------------------------------------+----------+----------+-----------+-----------+----------------------|
| MEAN   16.8    6.0      .00  11.66| .86   -.2| .57    .0|           | 87.5  82.3|                      |
| P.SD    2.3     .0    32.63    .56| .46    .9| .36    .4|           | 13.8   2.2|                      |
-----------------------------------------------------------------------------------------------------------
```

Figure 28: Item Statistics

An explanation of some of the headings used for the purposes of understanding the Item Statistics:

♦ Entry Number: The number allocated to the item: Class A = 1; Class B = 2; Class C = 3 and Class D = 4

♦ Total Score: This is the total (sum) score on a Class obtained by all participants using the **TPACK rubric** scoring.

♦ Total Count: The number of participants in the research project who answered and were scored using the TPACK rubric.

♦ Measure: linear unidimensional scale that allows a measure of an observed hierarchy with respect to the order of item difficulty.

♦ Item: Is the name of the Class e.g. Class D = 4 = Content, Pedagogy and Technology (combined together).

According to Liu (2002) the items with a respectable theoretical data FIT have INPUT AND OUTFIT **MSQ standards in the levels of 0,75 and 1,3** and INFIT and OUTFIT **standards between 2,00 and - 2,00.**

Although participants 2, Mr Johns (MSQ INFIT 1, 35 and OUTFIT 1, 09) falls above good data and 3 (MSQ INFIT 1, 30 and OUTFIT 0, 70) have MSQ values just at the range of 0, 75 and 1, 3 because of their responses as explained and is shown in *Figure 21* but they all lie within a valid statistical data model that lie between 2, 00 and -2, 00 as was be clearly shown below on the bubble map.

On plotting the performance of participants of the four item-classes of TPACK construct, the following bubble map was obtained: Figure 24: Bubble Chart

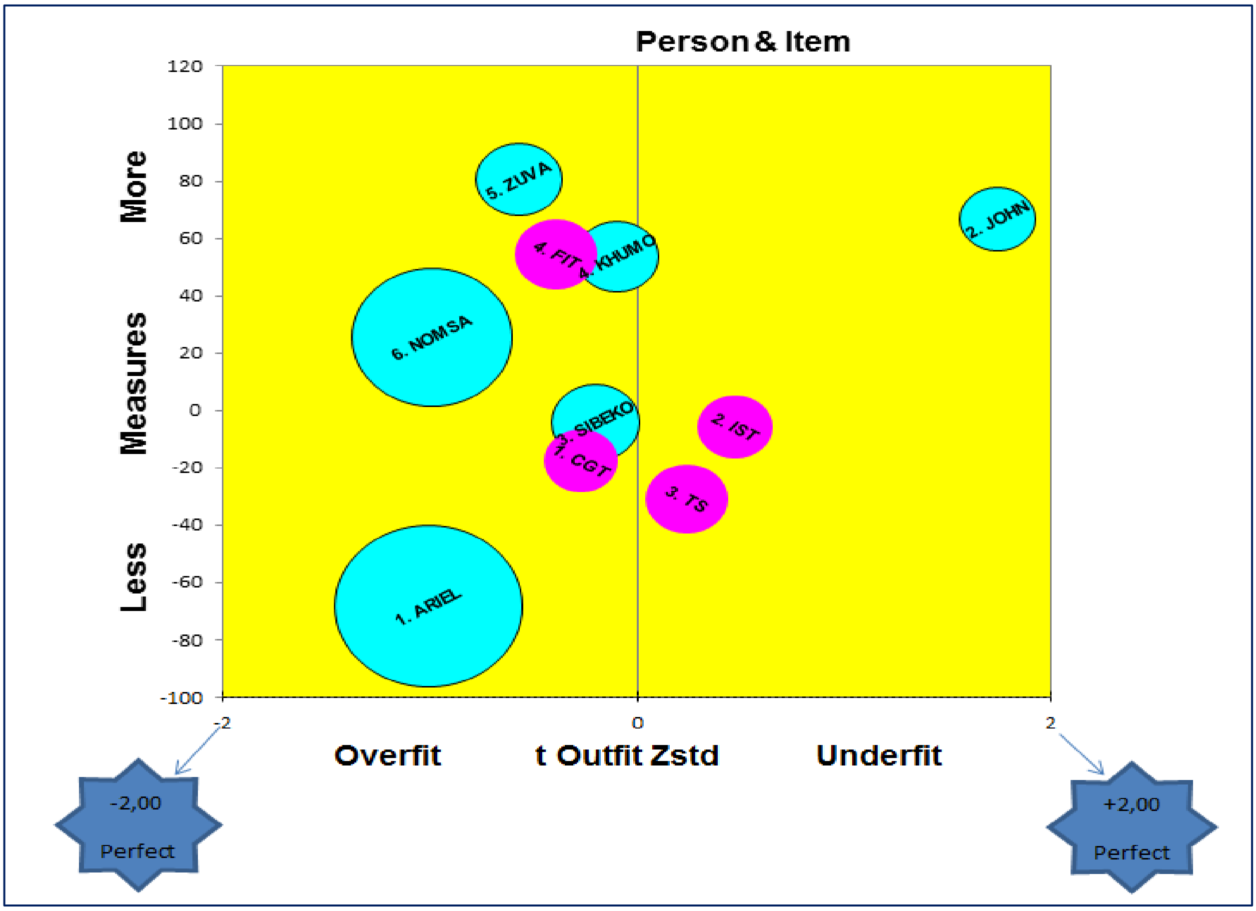


Figure 29 Bubble Chart indicating items with a good model data FIT

Abbreviations of the Bubble Chart

T.S. – Technology Selection

I.S.T. – Instructional Strategies and Technology

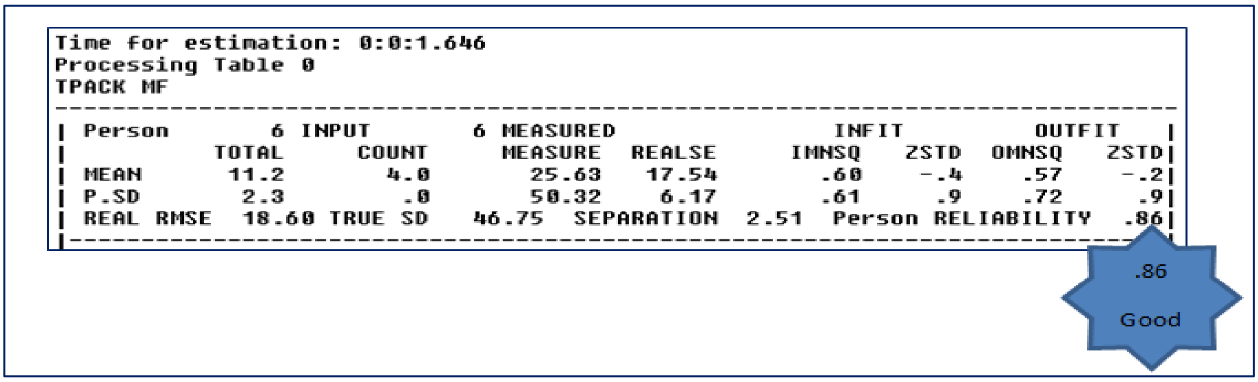
C.G.T – Curriculum Goals and Technologies

Fit – Content, Pedagogy and Technology combined

My findings show that, according to item difficulty and person ability measures my group fall within the fit statistical range of +2 and -2, as shown in fig 4 above. This was considered a perfect match, logical, conventionally suitable and hence indicating that the items and the person measures work together to measure a distinct construct, and therefore establishing a valid measure for Technological Pedagogical and Content Knowledge.

The results show small and big bubbles for persons and classifications. The smaller the bubbles the more coherent the persons are to the influences of the classifications. The bigger the bubbles the more unbalanced was the performance of the participant to the classifications or the latent traits being investigated.

4.7.2. Measure of Reliability

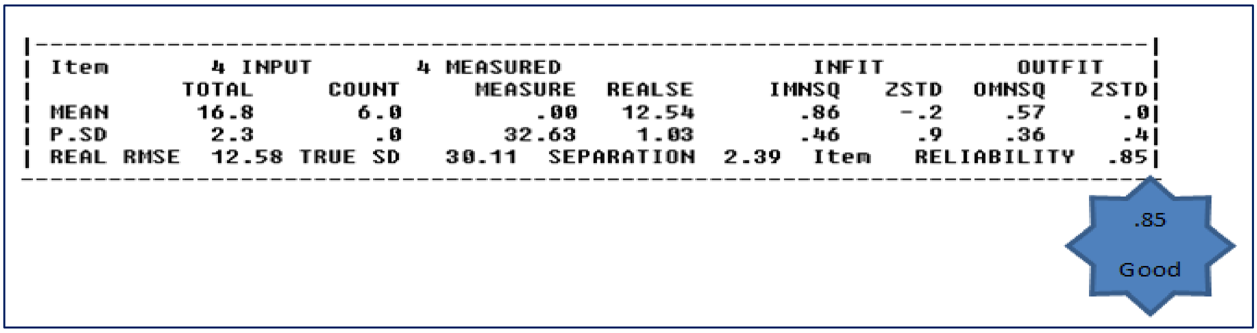


Time for estimation: 0:0:1.646
Processing Table 0
TPACK MF

Person	6 INPUT		6 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	11.2	4.0	25.63	17.54	.60	-.4	.57	-.2
P.SD	2.3	.0	50.32	6.17	.61	.9	.72	.9
REAL RMSE	18.60	TRUE SD	46.75	SEPARATION	2.51	Person	RELIABILITY	.86

Figure 30: Person Reliability

According to Linacre (2012), a reliability index point to the tendency of replication of relative measure location. Wright and Masters (1996) point out that the *person reliability* index designates replicability of individual collation if the same individuals would respond to another set of items measuring the same theory. A high *person reliability* index specifies that scores have a respectable range from low to high and henceforth a good range of scores of individuals in the model that answered to the instrument. This advocates that trust can be placed on the constancy of implications or conclusions drawn from the study.



Item	4 INPUT		4 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	16.8	6.0	.00	12.54	.86	-.2	.57	.0
P.SD	2.3	.0	32.63	1.03	.46	.9	.36	.4
REAL RMSE	12.58	TRUE SD	30.11	SEPARATION	2.39	Item	RELIABILITY	.85

Figure 31: Item Reliability

According to Bond and Fox (2001, p. 32) the *item reliability* index signifies the replicability of item collation if these same items were offered to a different but comparable section of participants. Bond and Fox uphold that high *item reliability* advocates that the tools used had both easier and difficult features and thus trust can be retained in the implications. Combined with these reliability indices, are Item and Separation Indices. The separation indices are used to categorize participants according to their capacities while item separation indices are used to substantiate item difficulty grading (theory rationality). *Item separation* index of bigger than 3 and item reliability bigger than 0.9 was satisfactory to endorse item difficulties grading (concept legitimacy). On the other hand, person separation index greater than 2 and an individual reliability index greater than0.8 are quite adequate to indorse individual capacities i.e. high high-fliers from low capabilities (Linacre, 2012, p. 574).

In this project, the person and item reliability indices of 0.86 and 0.85 are greatly satisfactory to confirm the consistency of the TPACK instrument, but however the individual separation of 2.51 and item separation of 2.39 established that there were features which were very puzzling for the participants because they fall below the equivalence of 3 (FIT- Content, Pedagogy and Technology combined together and Instructional strategies and Technologies). The item-person map displays both items (in terms of their difficulty) and individual (in terms of their capability).

4.7.3 Person – Item Map

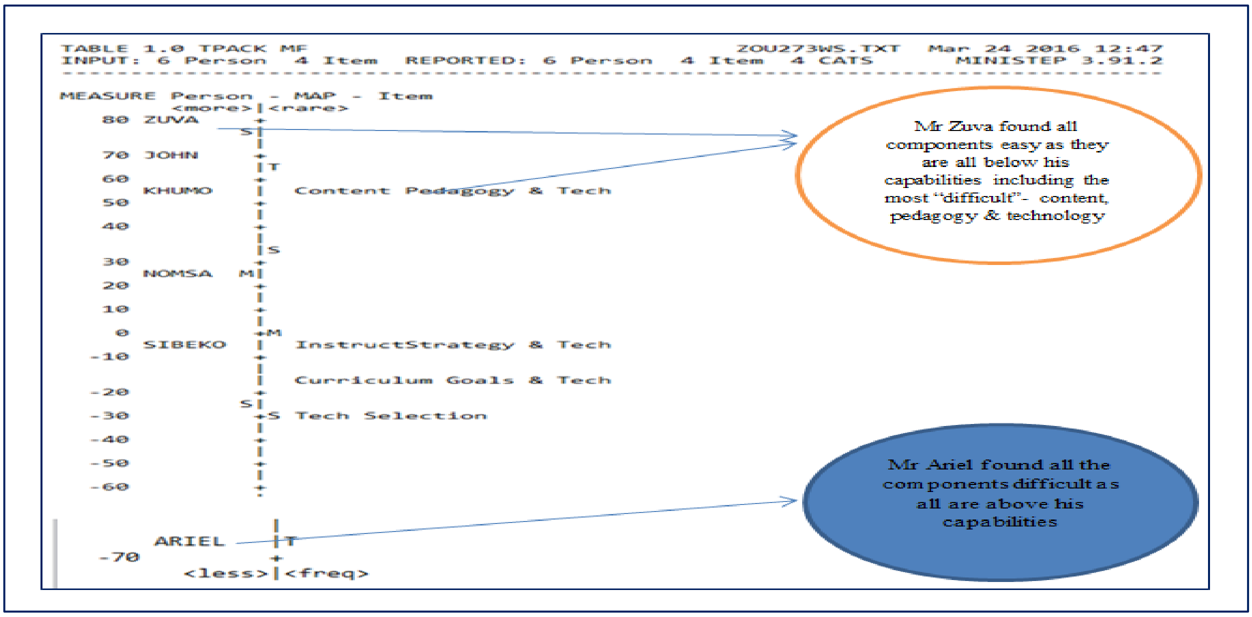


Figure 32: Person- Item Map shows both items (in terms of difficulty) and persons (in terms of capability)

The person- item map shows both items (in terms of their difficulty) and individuals (in terms of their ability). These range along a conjoint vertical axis with an internal scale in logits (Callingham and Bond, 2006). The item-person map makes it likely to visually analyze both the distribution and the link between the participants.

My findings indicate that on the persons, the map shows that Mr Ariel had a difficulty in classes measured as he was located below all of them. Mr Sibeko and Ms Nomsa shows that both of them had difficulty with one item (Fit) and could manage all the other three. But between the two of them in comparison of linear scale Ms Nomsa performances are much higher than that of Mr Sibeko. Although Mr Khumo's performance was higher than Messrs. Ariel, Sibeko and Ms Nomsa, the performance on (Fit) was indicated as being at par with the level of performance and the probability of doing well and not so well being 50%. Mr Johns for a person who was self-taught, he was higher than the other 4 participants but below Mr Zuva. Mr Johns finds the tasks relatively manageable and could do them well. But if one looks at the bubble chart, it shows him on the far right and this was because of unanticipated responses off-target items (de Bruno, 2011). Mr Zuva was the one who could manage all the items very well and was the highest.

The left side of Figure 27 shows participants and the right side shows the items. The left side of the map shows the distribution of the measured capability of the participants from the most capable at the top and the least proficient at the bottom. The items on the right side of the map are scattered from the most challenging at the top, to the least demanding at the bottom. On the left of the central vertical axis of the map shows the MEAN (M) and two standard deviation points (S = one SD and T = SD) for measuring participant's capability.

On the right side of the central vertical axis the main difficulty of the items (M) and two standard deviation points (S = one SD and T = two SD) for items are shown (Lunz, 2010). Lunz explains that when participants and items are compared to each other on the map, the difficulty of the item and the ability of the participant can be simply linked. The participant has approximately a 50% possibility of responding appropriately.

My findings indicate that on the items conceptual difficulties from the component Instructional Strategies and Technologies to Content, Pedagogy and Technology combined together with a wide spacing of 60 logits (20 logits to 80 logits) compared to an average spacing of 10 logits between other components. Two of the participants (Zuva and Johns) were able to navigate that transition with easy, one participant (Khumo) was on average and the rest could not manage with the nearest to Khumo having a spacing difference of 20 logits. Lastly, all the participants had a 50% chance of managing the tasks in the instruments as they are all above the mean except for one (ARI).

4.7.4 Item Measure

The Rasch model permits the formation of a grading system of difficulties of the particular classes of the construct TPACK that the group of participants encountered in the instrument. The item grading system of the recorded data is presented below. The thumb- rule was that the greater the Rasch value, the more challenging the item. Content, Pedagogy and Technology together were the most difficult item and Technology Selection the easiest.

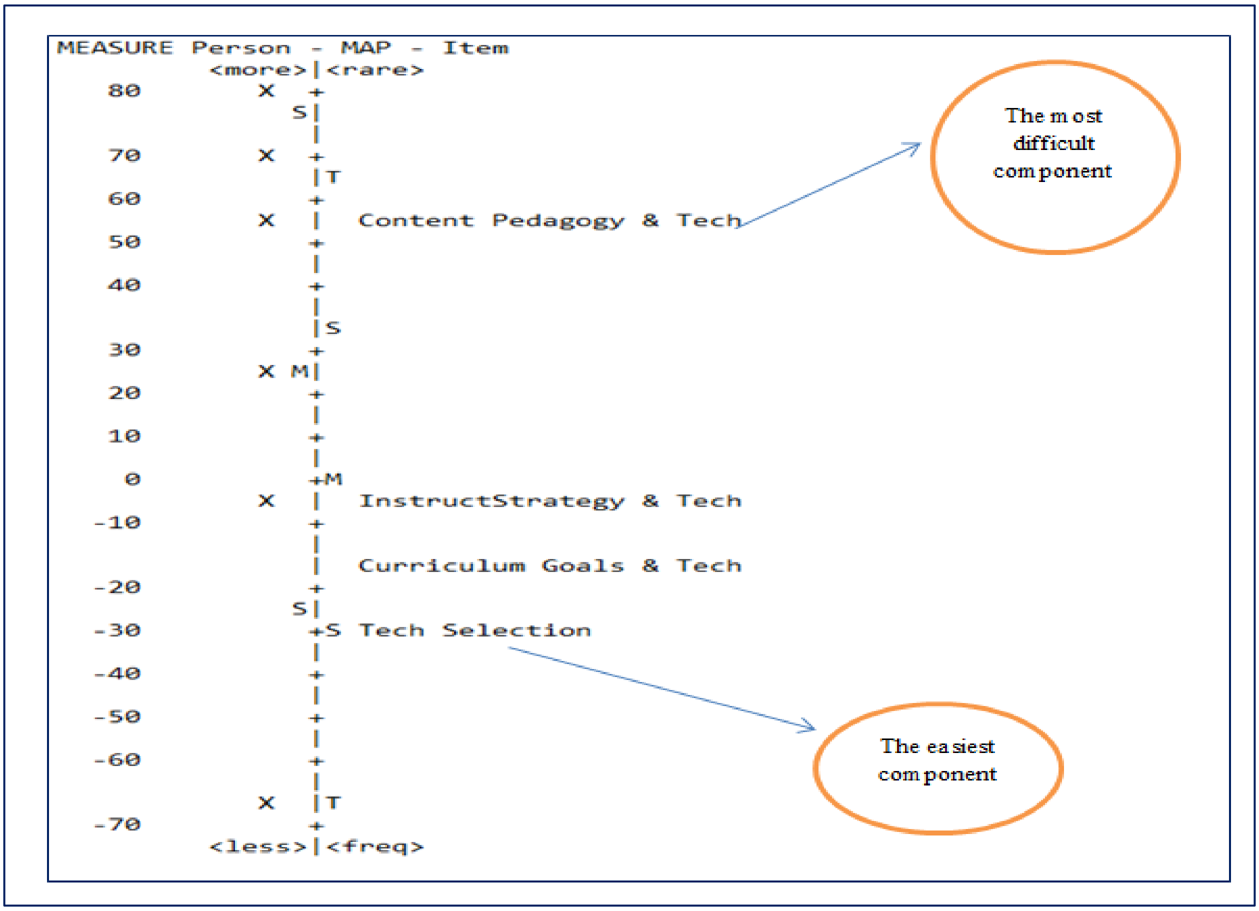


Figure 33: Item Measure

As a suitable initial point for plotting process, the mean of the item difficulties is assumed by default as zero points. Individual positions are plotted so that any individual has a 50% likelihood of succeeding with an item placed at the same point on the logit scale. An individual with a capability estimate of 0 logit has a 50% likelihood of achieving on items more difficult than the item below the scale and that same individual would have a better than 50% prospect of succeeding on items more difficult than the item on 0 logit and a less than 50% possibility of succeeding on items more difficult above the scale (Bond et al, 2001)

4.7.5 Item Characteristic Curves (ICC)

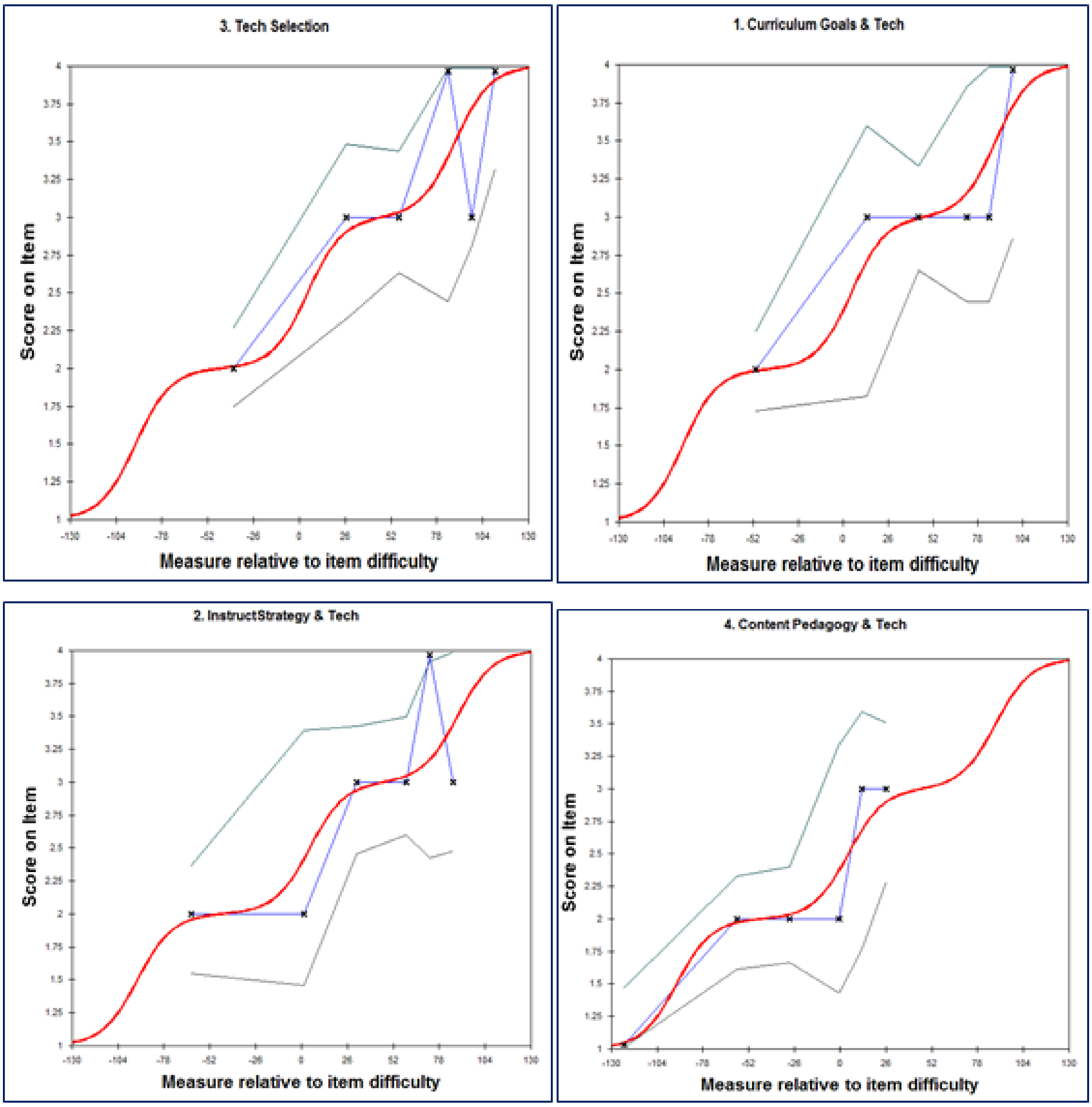


Figure 34: Item Characteristic Curves (ICC)

The depictions above show the relationship between the individual's capability and how difficulty a given classification in the TPACK rubric assessment was which is known as PERFORMANCE of an individual on that classification(i.e. A,B,C, OR D) - a given quality of the TPACK construct characterized by each class on the rubric. Hernard (2000) suggested that this concept of achievement can be symbolized by an item responsive graph. This graph is called as the Item Characteristic Curve (item individual graph). ICC therefore explicitly demonstrates the relationship between a person’s answer to an item and the underlying characteristic measured by the scale. The gradient of the graph fluctuate as a function of the capability level, attaining a maximum value when the capability level is equivalent to that of the item’s difficulty.

The sharper the curve, the better the item can differentiate and the flatter the curve, the less the item is able to distinguish. This was because the possibility of both high and low capability levels of appropriately approving the item was essentially the same. The vertical axis shows the possibility of a participant approving an item and the horizontal axis reveals the underlying attributes (de Bruin, 2011).

My findings indicate that firstly, Fit (Content, Pedagogy and Technology) shows low level gradients on score on items of as low as 1 to 3.75 and Measures to item difficulty of as low as   -130 to +24. This indicates that on this sample of participants, this item was the most discriminating of all of them.

Secondly instructional strategies and technologies show middle low gradients on score items of 1.5 to 3.75 and Measures to item difficulty of as low of - 59 to + 101. This indicates that this sample, although had difficulties on this component, it was not as “harsh” as the Fit component because measure gradient was almost half.

Thirdly Curriculum goals and Technologies shows middle, high gradient on score on items of 1.75 to 4 and Measures to item difficulty of – 42 to + 75 and lastly Technology Selections show high levels of on score items of 2 to 4 and Measures to item difficulty of as low of - 24 to + 134.

These curves shows clearly which component requires attention among the participants and which components require less input. This leads to the discussion of the importance of all this statistical analysis.

4.8 The Significance of the Findings

The main purpose of the project was to determine the extent of effective use of ICTs for effective teaching and learning (a kind of educators' knowledge called TPACK) of the Grade 10 Physical Sciences topic of Mechanics by six educators in three high schools in Gauteng province. The process of collecting data consisted of two phases, the first in which the TPACK instruments were administered to the six Grade 10 Physical Sciences educators and the second phase dealt with the procedures and marking of instruments using the **TPACK rubric**. I marked the participants‟ responses with the approved **TPACK rubric** first and then invited an independent peer rater to also mark the responses. Our scores were compared and where there were disputes, scores were changed after a compelling argument was provided. This step was done to validate the scores and check the consistence of the scoring process. An agreement of **79%** was observed. An average TPACK rating score of **3 (Developing)** was obtained.

The raw scores from the TPACK rubric were analyzed by the Rasch model (MINISTEPS) which converts raw scores into probability scores of equal interval. The Rasch model summarizes completely a person's standing on a trait, in this case, TPACK. It was also used as evidence of the validity of the instruments as well as provides an estimate of internal consistence of items. Here the persons and item reliability indices were determined as well as the rank or hierarchy of classes of TPACK according to item difficulty.

An analysis of raw scores using the Rasch Model, the validity of the TPACK construct was found to be appropriate with the predictable range of Fit statistics of **-2 and +2.** It was considered a respectable general fit of the available information. The internal reliability of assessment items as measured by Cronbach's alpha **KR-20 was 0.88** inferring that the tool contains both easy and difficult assessment items.

```
Person RAW SCORE-TO-MEASURE CORRELATION = .99
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .88  SEM = .79
```

Figure 35: The internal consistency of test items as measured by Cronbach's alpha

The value shows high internal consistency of assessment items and this reveals that all persons of different capacities were accommodated for. The Rasch Statistical model produced a very good individual dependability measure of **0.86** implying that if the equivalent participants were offered alternative set of similar items that measures the same hypothesis, the equivalent findings would be attained. This great consistency measure of **0.86** designates that there were wide-ranging scores that were achieved fluctuating from low to high and this is suggestive of reliability.

Furthermore, the item reliability amount was at **0.85**. Since the item reliability displays the reproducibility of the similar findings if the items were given to another group of the equivalent type, there are very good prospect likelihoods of getting the identical outcomes since the item reliability was way beyond the average 0.5 percentage likelihood marks. In the item map, the items are extended almost about the mean indicating a reasonable distribution of item difficulty.

The most challenging instrument items were on Content, Pedagogy and Technology combined together while the least demanding assessment items were on Technology Selection. The item difficulty grading order was a follows from the minimum to the most difficult:
Technology Selection < Curriculum Goals and Technologies < Instructional Strategies and Technologies < FIT (Content, Pedagogy and Technology together).

Figure 4-36 Order of difficulty according to TPACK classifications

Item Difficult Ranking Order			
Technology Selection(s)	Curriculum Goals and Technologies	Instructional Strategies and Technologies	FIT(Content, Pedagogy and Technology together)
<	<	<	<
-31	**-18**	**-6**	54

This performance by educators was supported by the Item Characteristic Curve. ICC graphically illustrates the relationship between an individual's response that was low to average to an item and the quality of classes being measured. It clearly showed that the item most selective was Fit (Content, Pedagogy and Technology) and the least impeding was Technology Selection(s).

In conclusion, the instruments showed a high amount of validity and reliability in measuring the extent of TPACK of participants in the teaching and learning of Mechanics in Grade 10. The theoretical prediction agrees with the empirical prediction thereby indicating that the construct of TPACK was valid. The person and item reliability indices were found to be acceptable as they were above **0.5.** 0n computing the Infit and Outfit statistics it was established that the theoretical construct was valid as the persons and items were found to be within **-2 and +2.** This implies that both the individuals and the assessment items function together to measure the same underlying attribute - which was TPACK in this case.

Participants" explanations did not show much depth of TPACK and hence the majority of participants demonstrated basic TPACK. The teachers performed well in the Technology Selection classification and poorly in the Fit (content, pedagogy and technology together) classification**.** The interpretive argument agrees with the calculated validity and this also gives further evidence of instrument validity. The order of item difficulty hierarchy was summarized as follows *Technology Selection < Curriculum Goals and Technologies < Instructional Strategies and Technologies < FIT (Content, Pedagogy and Technology together).* This confirms the theoretical postulation that most practicing teachers usually struggle in the FIT component of TPACK than in Technology Selection. This means that the FIT was of higher order only persons with higher ability could answer such test items. The reason for the difficulty experienced in FIT was probably because it draws from all the other knowledge components. This means that the individual should draw from all the knowledge components and bring them together, by this I mean that s/he should have sound knowledge on how select appropriate Technology, versatile with the relationship between curriculum goals and technologies and in-depth coordination of Instructional Strategies and Technologies to teach and sequence them appropriately to effectively teach with ICTs. This also point out the validity of the TPACK instrument since observed confirmations and hypothetical point of view support the fitness of descriptions and activities grounded on assessment tallies (Messick, 1989).

4.9 Conclusion remarks

The quantitative methods employed in this research project dealt with the numerical aspects of traits of an underlying construct, the need to quantify the traits and make them measurable for comparative purposes. The traits in the ICT integration in teaching - (i) Curriculum Goals and Technologies (Curriculum-based technology use), (ii) Technology Selection(s) (Compatibility with curriculum goals and instructional strategies), (iii) Instructional Strategies and Technologies (Using technology in teaching/ learning), (iv) Fit (Content, pedagogy and technology together) - although known and researched by others, not much was known about their quantification and ability for comparison. In this chapter, an attempt was made to convert narratives of ICT integration traits into the teaching of Mechanics into numerical quantities to determine the extent of ICTintegration between each case under the study. The results showed that the most competent educator was Mr Zuva and the most difficult trait educators encountered as a sample dealt with was Fit (Content, pedagogy and technology together and the most easiest was Technology Selection(s). This means as practicing educators this aspect of the study shows were ICT integration need support and guidance. Each case can have a Programme of improvement plan designed because an area of weakness has been identified. This analysis chapter helped in responding to research question 1.

4.10 Projection to the next chapter

The next chapter deals with Qualitative Analysis of the extent of TPACK and the Contextual Variables affecting TPACK. It ends with the discussion on the significance of the findings.

CHAPTER 5

Qualitative Analysis

The previous chapter was a Quantitative Analysis dealing with the analysis of the TPACK rubric assessed outcomes; I deliberated on how the answers were quantified and how the quantities were normalized in the Rasch statistical model. This permitted the analysis, which allowed the evaluation of the validity and the reliability of the items and the persons. In enumerating the responses to generate scores, some responses were analysed and explanations were given on how the descriptive scores were converted to quantitative scores. In this chapter I did dwell on the quality of the responses, how I used them to shed light to the overall comprehension of Question 1 and finally to provide a qualitative analysis that assisted in responding to *Question 2 dealing with the contextual variables that affect the pedagogical integration of ICT in the teaching of Mechanics in these high schools of the participants.* Contextual variables they are like "water and fish", all the TPACK theoretical construct variables and their respective interplay take place within contexts; they are both needed to understand ICT integration.

5.1 Overview

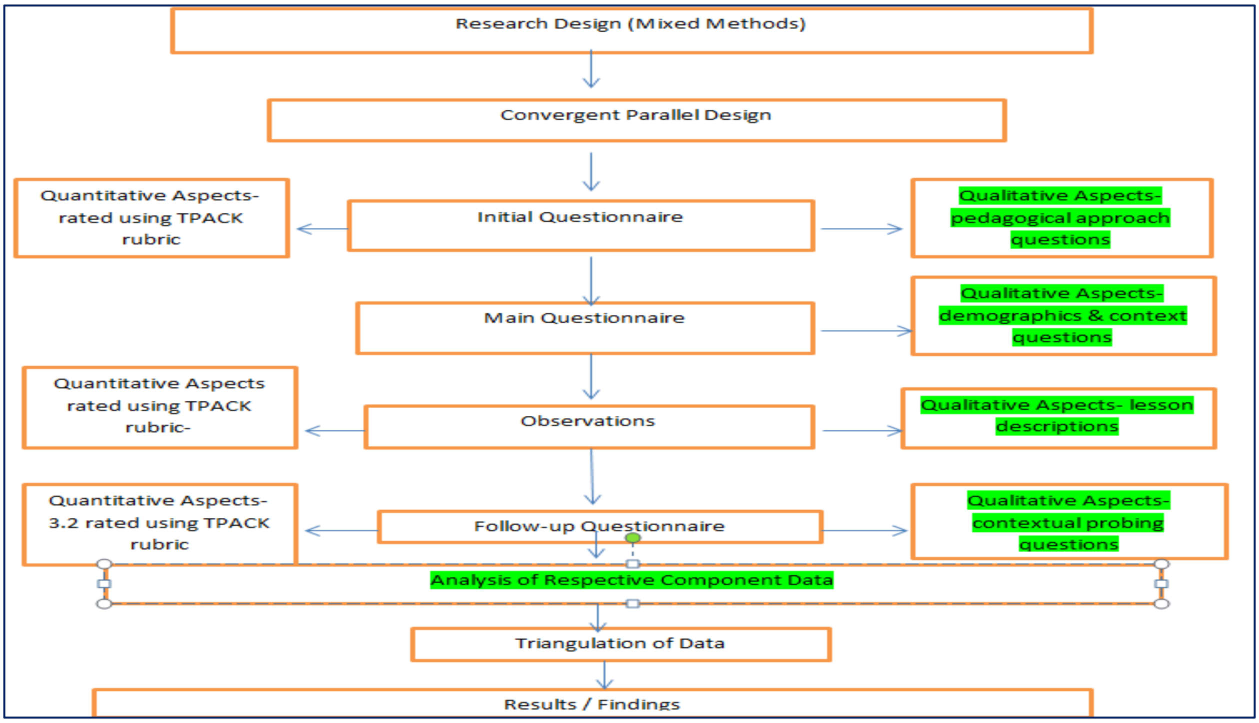


Figure 37: Qualitative Sequence of data collection

As mentioned in the previous chapter, the aim of these Analysis chapters is to examine data from the participants teaching the topic of Mechanics using ICTs in order to determine the extent of ICT integration and obtain insight into the contextual variables affecting ICT integration.
In this chapter the Qualitative Analysis was composed of the aspects shaded in Green on the diagram shown on the previous page and the aspects explained below:

The qualitative analysis aspects were obtained firstly from the initial questionnaire *(see consolidated summary response tables of initial questionnaire questions, Appendix A4),* whose scope dealt with the pedagogical approach questions, secondly the Main Questionnaire*(see consolidated summary response table of Questionnaire questions, Appendix10)*whose focus was on demographic questions and ICT content, thirdly the observation schedule*(see consolidated summary response tables from observations, Appendix 8)* which was a result of in-situ class observation and lesson descriptions and lastly a follow-up questionnaire*(see consolidated summary response tables of follow-up questionnaire questions, Appendix 12)* that contained contextual probing questions to highlight variables of context that could hinder or enhance ITC integration.

Therefore the analysis below did try to show from the responses of the participants the broad spectrum pattern of the responses that illustrates that indeed the educators exhibited a developing *TPACK rating* and the contexts in which ICT integration was occurring.

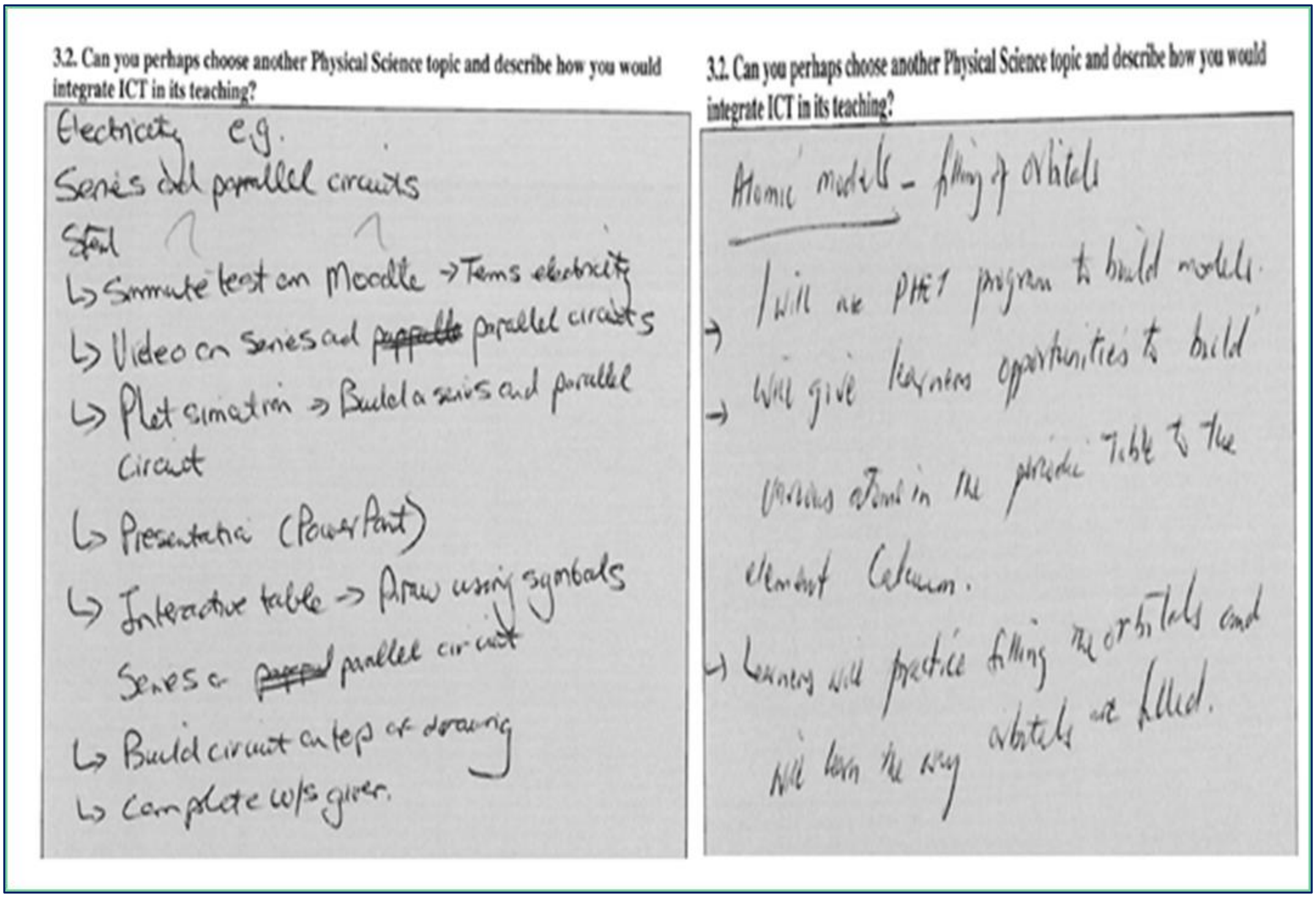
5.2 Qualitative Analysis

In the previous quantitative analysis chapter, I had mathematically determined the mean score of the TPACK construct using the scores obtained in the classifications (*see figure 4-40).* The physical science educators using ICTs obtained an average rating of 3 which corresponded with a Developing stage on the TPACK rubric. Now only the responses were be analyzed.

5.2.1 Curriculum Goals and Technologies (Curriculum-based technology use)

The criteria for evaluation in this category followed that educators had to demonstrate if the technologies selected for use in the instructional plan of Mechanics topic or any other topic of their choice *(see question 3.2 of the follow-up questionnaire A11)* was either strongly aligned, aligned, partially or not aligned with one or more curriculum goals. Although the NCS and Caps documents are not explicitly curriculum-based technology the educators seemed to be able to identify curriculum goals that they can link with the technology in order to produce a coherent lesson in Mechanics as shown in the previous chapter *(see section 4)* or any other topic of their choice. Since I have used most of the Mechanics lessons in the previous chapter as examples, in this case I would like to use the topic of their choice to exemplify curriculum goals and technology selection in Class A: (the two educators whose extracts are below chose Electricity- Parallel and Series circuit and Atomic Models respectively part of the CAPS based content in Grade 10).

Extract from Follow-up Questionnaire Q 3.2 (Appendix A11, A12 Mr Zuva and Mr Ariel)



3.2. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

Electricity e.g.
Series and parallel circuits
Start
↳ Simulate test on Moodle → Terms electricity
↳ Video on Series and ~~parallel~~ parallel circuits
↳ PhET simulation → Build a series and parallel circuit
↳ Presentation (PowerPoint)
↳ Interactive table → Draw using symbols Series a ~~parallel~~ parallel circuit
↳ Build circuit on top of drawing
↳ Complete w/s given.

3.2. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

Atomic models - filling of orbitals
→ I will use PhET program to build models.
→ Will give learners opportunities to build the various atoms in the periodic Table to the element Column.
→ Learners will practice filling the orbitals and will learn the way orbitals are filled.

Figure 38: Comparison of best practices of ICT integration lesson descriptions

In the first extract Mr Zuva rightly chooses the example of electricity as curriculum goal and shows an array of selected technologies to achieve the teaching of the topic. In the second extract the Mr Johns selects the Atomic model part of the atomic theory to illustrate how he did use a technology selected to achieve curriculum goals. This class of the TPACK construct was done well with most participants on rating 3 or 4 except for one i.e. technologies selected for use in the instructional plan are aligned **(rating 3)** or strongly aligned **(rating 4**) with one or more curriculum goals.

5.2.2 Technology Selection(s) (Class C) (Compatibility with curriculum goals and instructional strategies)

In the Technology selection(s) item the measure of criteria followed that participants had to exhibit that technologies selected are either exemplary given curriculum goals or instructional strategies, appropriate but not exemplary, marginally appropriate or inappropriate.

Extract from Initial Questionnaire Q 2 (Appendix A3, A4, Mr Ariel and Ms Nomsa)

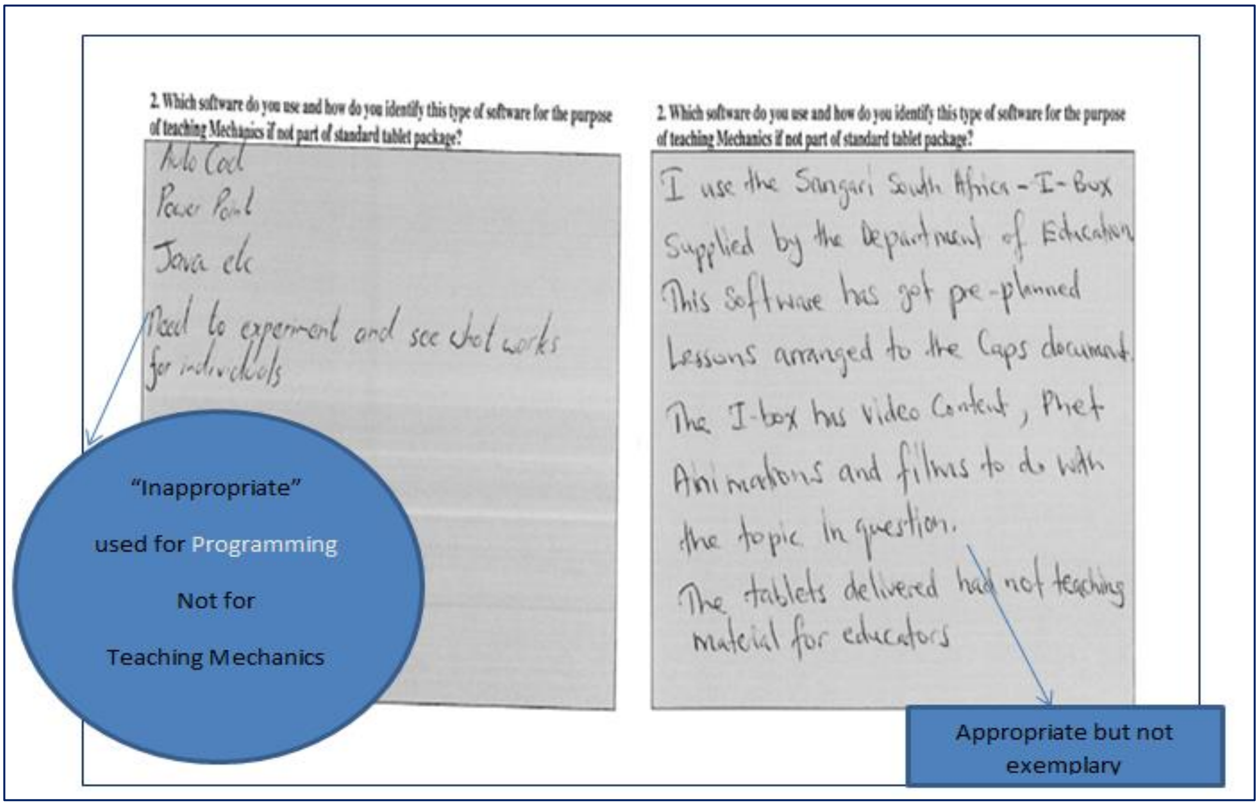


Figure 39: Comparison of developing practices of ICT integration lesson descriptions

All our participants mostly associated technology selection with its compatibility with curriculum goals only, but not with instructional strategies. This was evidenced by their mentioning equally the same technologies like PowerPoint, PhET simulations, Ms Word processing randomly without explaining the pedagogical and conceptual teaching reason for doing so as required in Conceptual, Procedural or Expression building techniques *(see appendix A7a-c).*

Although educators were considered to have done well on this section, the **rating of 3 (**i.e. technologies selected are appropriate but not exemplary) but averagely good for them because it shows there was a positive room for improvement.

This was a slide in which an educator does not conceptualize well technology selection for instructional strategies: Extracted from Follow-up Questionnaire Q 3.2 (Appendix A11, 12, Ms Nomsa)

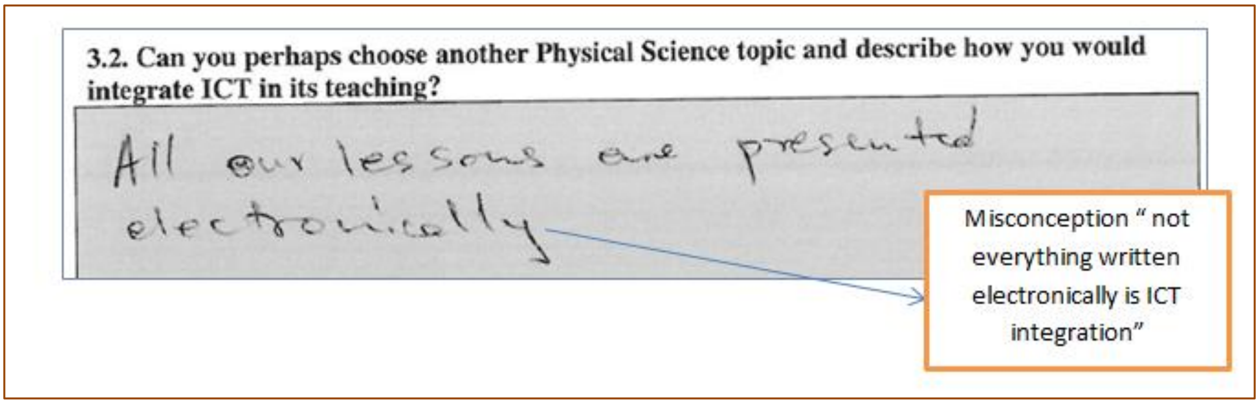


Figure 40: Teacher's thoughts about ICT integration

This slide show the participant was of the mistaken concept that when all lessons are in electronic form that was ICT integration and also that constitutes technology selection. It was not judging from the criterion measures.

This leads to the next TPACK trait that was not well conceptualized by the participants:

5.2.3 Instructional Strategies and Technologies (Class B) (Using technology in teaching/ learning)

Instructional strategies measures consisted of whether educators were able to demonstrate that the technology they use either optimally supports instructional strategies, just supports, minimally supports or does not support instructional strategies at all. This category corresponds with the predictions made in literature on measuring TSPCK (Mavhunga, 2012) of practicing Physical Science educators. According to Mavhunga, this category was one of the toughest of the measured attributes (teachers generally perform poorly). This was also confirmed by the item location parameter or item map in section **4.7.4** produced by the Rasch Statistical Model on the TPACK construct measures in this project. Let us examine two extract responses by two participants:

Extracted from Initial Questionnaire Q 2 (Appendix A3, A4, Ms Nomsa)

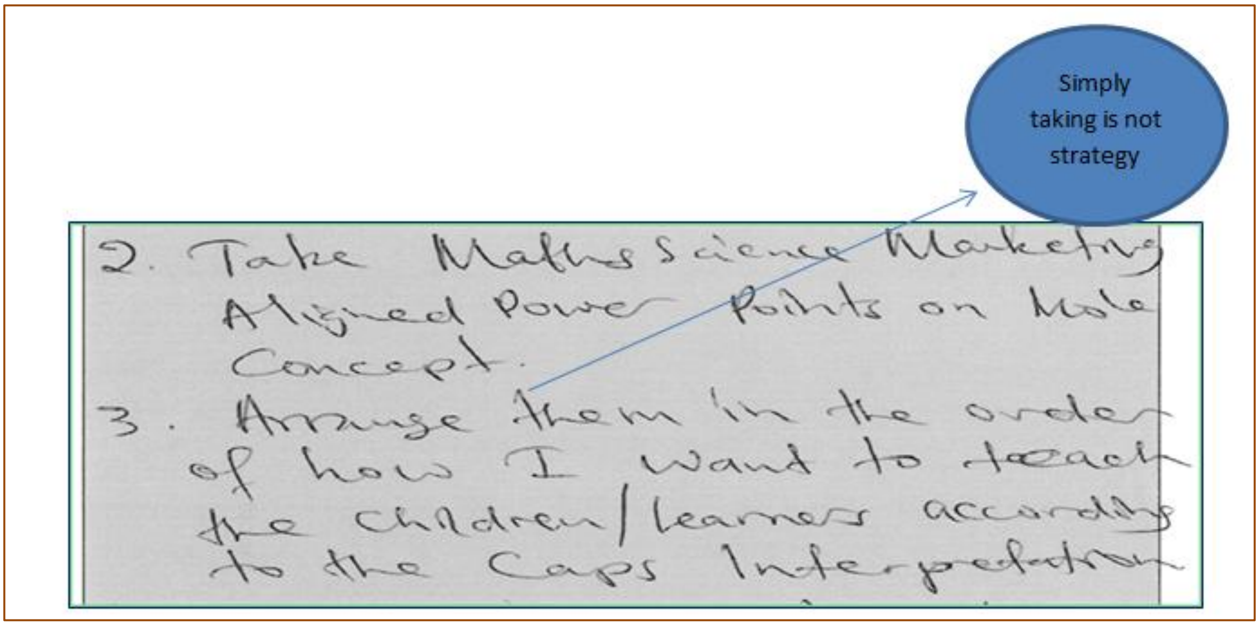


Figure 41: Nomsa on Instructional Strategies

Ms Nomsa was displaying the ability of information dissemination erroneously taken as instructional strategies. This was whereby slides are packed together with data and learners are made to copy information and there was no ICT instructional strategy at all.

Extracted from Initial Questionnaire Q 2 (Mr Johns, Appendix A3, A4)

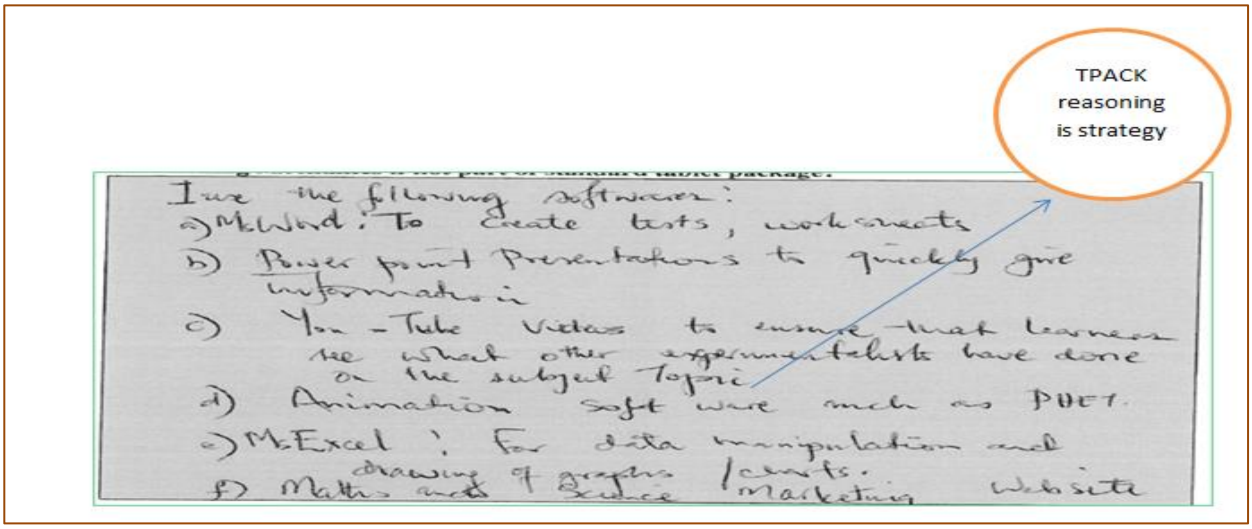


Figure 42: Johns on Instructional Strategies

Whilst Mr Johns makes a sequence of instructional strategies of how his lesson ought to follow using technology: MS word to create texts and PowerPoints falls under knowledge expression strategies *(see Appendix A19)* in the teaching of Mechanics, Animations are for Conceptual building exercises (*see Appendix A18)* and finally Excel or use of spreadsheets was under Procedural building strategies *(see appendix 17).* This was also exemplified by Mr Ariel seriously in his Mechanics lessons.

As stated above with Mavhunga case there seemed to be an agreement on instructional strategies, with the TPACK construct as measured in the project as it confirms also that instructional strategies are also difficult. I.e. those instructional strategies are difficult. Instructional strategies involve the use of technology to confirm or confront learner's prior knowledge and/ or common misconceptions. They involve sequencing a lesson based on important conceptual aspects that makes comprehension of the topic easy to learn. It refers to the use of combinations of conceptual principles and rules of a topic as the tools using technology to confront the potential confusion and misconception. This seems to be an aspect not located in the most responses of participant's hence only Mr Zuva and Mr Johns exhibited well-grounded characteristics of this concept. Finally this this leads to the last TPACK trait that was the most difficulty to execute by most participants:

5.2.4 Fit (Content, pedagogy and technology together)

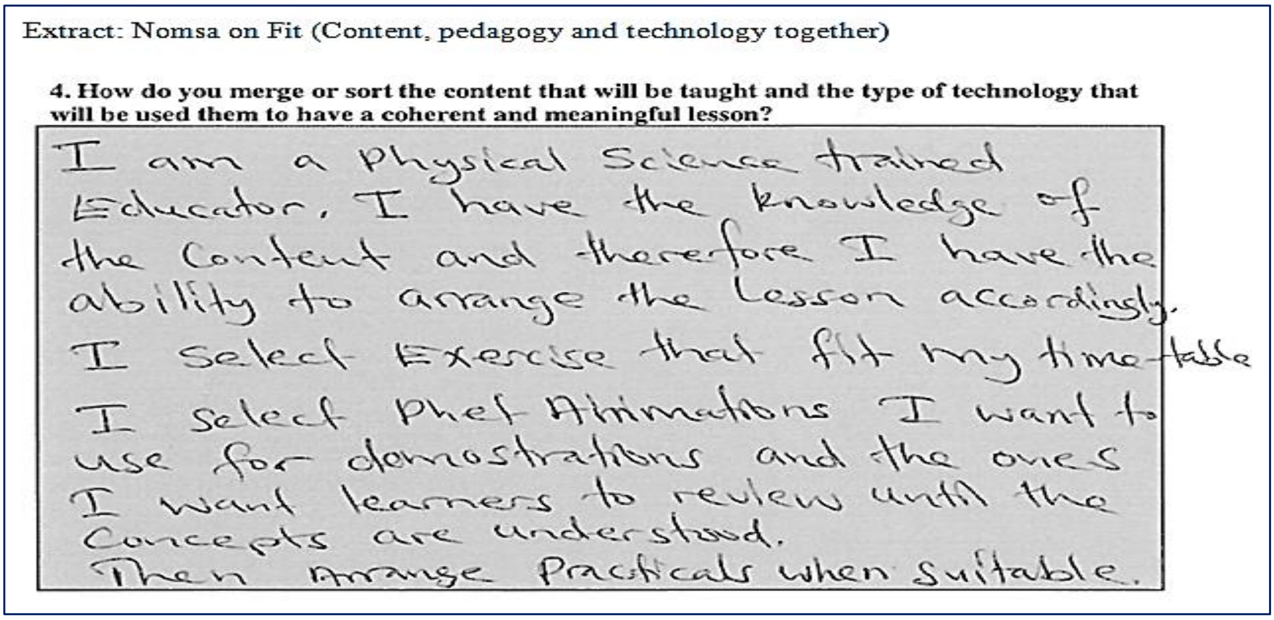
Fit measure criteria envisaged educators to demonstrate the ability to either Fit together strongly within instructional strategies the content and technology, just fit together, fit together somewhat within or not able to fit them together at all.

This was the most difficulty of all categories. The findings show that not even one participant was up to standard and those who showed effort were still at the developmental stage in the ICT integration. This was probably so because the whole concept involves the knowledge of all categories including the most mistaken or erroneously conceived ones exemplified by instructional strategies and technology coupled with technology selection for instructional strategies. The extracts and descriptions given below are selected based on the observations in the project.

Table 22: ICT artefacts used by participants in context A5, A6

	TPACK (Fit)		
	Technology	Content	Pedagogy
NOMSA	Using I-box technology	Integrated (Notes)	Less conceptual
ZUVA	Using Interactive smartboard	Integrated (Books)	Conceptual
SIBEKO	Self-Improvised	Not Integrated (Both)	Moderately conceptual

Ms Nomsa used the I-box which on inspection was a very important tool. It comprised an integrated computer, sound system, projector with notes and many other integrated animation facilities in one system. It had an interactive interface between the main component and the learners' stickers that could be used during tests and exercise to respond and mark and process the assessments. Ms Nomsa relied on the content material integrated therein. During class observation, I discovered that some concepts were conceptually wrong, but Nomsa did not notice it because of what she called "pressure of the timetable ". She emphasized that the completion of the curriculum was important and the HOD must see that all was covered. The I-box facility was used below its maximum potential because she did not know how to optimize its potential. This I classified as a less conceptual teaching method. Extracted from Initial Questionnaire Q 4(Appendix A3, A4, Ms Nomsa)



Extract: Nomsa on Fit (Content, pedagogy and technology together)

4. How do you merge or sort the content that will be taught and the type of technology that will be used them to have a coherent and meaningful lesson?

I am a Physical Science trained Educator, I have the knowledge of the Content and therefore I have the ability to arrange the Lesson accordingly.
I select Exercise that fit my time-table
I select Phet Animations I want to use for demostrations and the ones I want learners to review until the Concepts are understood.
Then Arrange Practicals when suitable.

Figure 43: Extracted from Initial Questionnaire Q 4

Mr Sibeko had put together his laptop, projector, board and taken e-books and other materials to make a data bank for his teaching. The learners later obtained tablets from the GDE. He made interactive connections with the Bluetooth facility. He taught his learners how he wanted the gadgets used and when he wants them used. His facility enabled him to beam questions or work on one side and show working on the other, but learners were be fixed to one window on the Bluetooth facility. On inspection of the Mechanics content being taught, it was correct, but his sequencing of lessons needed improvement to make it conceptually coherent. Some activities seemed to be done as an afterthought. I classified this as moderate conceptual teaching: Extracted from Initial Questionnaire Q 4 (Appendix A3, A4, and Mr Sibeko)

Extract: Sibeko on Fit (Content, pedagogy and technology together)

4. How do you merge or sort the content that will be taught and the type of technology that will be used to have a coherent and meaningful lesson?

Most of all my lessons use technology to help learners not only understand the subject matter, but also help them get a working understanding on how to use the technology. I do try and use the tools and software according to lessons learned. E.g. The calculator on the tablets can be used to calculate difficult equations while the word processor can be used to type the answers. Answers can be send via Bluetooth and displayed on screen.

Figure 44: Sibeko on FIT (Content, Pedagogy and Technology together)

Mr Zuva used an interactive smart television, fully integrated with the CAPS complying books, past exam papers, high speed internet facility and inter and intra Wi-Fi technology. Another gadget in his possession was an Edutrade desk that allowed learners to learn how to practically and virtually carry out experiments covering the CAPS curriculum. He had been trained by the interactive manufacturers on how to optimize the use of the gadgets, Wi-Fi and high internet facilities were assembled with his input and of course his school administration. The tablets were all connected to his server and television. Teaching and learning were well sequenced as per the descriptions in the instruments of this project. His pedagogy, although conceptual was weak as he was more inclined to natural science than physical science. I classified his pedagogy as conceptual but can be improved more.

Extracted from Initial Questionnaire Q 2, A3, A4

Extract: Zuva on Fit (Content, pedagogy and technology together)

Interactive content used
3D designmate visualisation used.
Constant testing with instant feedback.
Making of video clips for teaching purposes
Making videoclips of experiments done to give to learners so that they can view experiment more than once

Figure 45: Zuva on FIT (Content, Pedagogy and Technology together)

This was how the whole evaluation of participants was covered, including Messrs. Ariel, Johns and Khumo. My findings show that educators come to ICT integration not as "blank slates" but with some expectations to use Information Technologies for good pedagogical purposes or intentions. As this was a new area of teacher knowledge, educators might have misconceptions on what ICT integration entails hence the failure to situate well selected technologies (by themselves participants) into proper instructional strategies. Instructional strategies are an area that was derived from training mostly. The average showing by participants in this category might have something to do with the manner of training because Mavhunga in topic specific pedagogical content knowledge measures also singles it out. The issue of Mechanics content being a difficult in South Africa (Equal Education, 2016; BDE, 2012, 2013) was well recognized and was undoubtedly another feature of why educators do not do so well to "Fit" the ICT integration aspects together.

However, the TPACK construct (*see Figure 2*) shows all the knowledge areas, interconnected but it was surrounded by dotted circle which represents the contextual variables affecting all those knowledge aspects. Contexts are not the same in the country, province, district, cluster and the school. There was a set of variables that impact more on everyone, but some more on one set of participants than others. A detailed description of the contextual variables affecting ICT integration in the schools of the participants is described below.

5.3 Contextual Variables

Batchelor (2014) in discussing challenges facing teachers when using ICTs identified the following educator related contextual variables: level of teacher competencies, nature of connectivity, policy issues, curriculum demands, accountability and CAPS aligned resources to licensing software, services, tools and applications among others and also those that affect institutions as a whole.
On the same issue, Dlamini (2014) addressing the same issues stated above said that pedagogical ICT integration does not subscribe to the one-size-fits-all situation as it is multi-dimensional as it situates itself at the intersection of social, political, economic and technical perspectives. In this project a number of aspects affecting ICT integration were investigated from participants and a comprehensive analysis is proffered below:

5.3.1 Educators varying level of competence to implement the ICT project

Participants	TPACK LEVELS
Ariel	1.75
John	3.25
Sibeko	2.50
Khumo	3.0
Zuva	3.5
Nomsa	2.75

Figure 46: Showing the varying TPACK levels of participants A9, A10

The quantitative results of this project as shown in the previous page indicate that the educators were at varying levels of Technological Pedagogical Content Knowledge some high and others very low. The project reveals that this might have been due to different reasons that include the number of years exposed to the ICT integration as shown in the table below:

Extracted from Initial Questionnaire Q7 (Appendix A3, A4)

7.

Pseudonym	To what extent has the training that you received from the (DoE) or (Name provider…….) to use ICT in the classroom been useful (i) for you lesson preparation, and (ii) with teaching your topic during class?
Mr Ariel	I never received training.
Mr Johns	Self-coached and no formal training was given.
Ms Nomsa	• Sangari South Africa taught us how to use their programmes. • Involves setting the Power Point • Where to source animation & video content. • How to set clickers in order to carry out evaluation (although difficult at times). • How to do evaluators and how to access outputs.
Mr Zuva	• Training from Intel – Better organisation of files and classroom dynamics. • Better presentation quality in my PowerPoints. • Training from SMART – Confidence in using interactive board. • Training from I School Africa to make video clips.
Mr Khumo	• Trained by the master trainer of DBE • Training by intel and proline manufacturers of the white interactive smart tv • Training from school Africa to make videos and animations
Mr Sibeko	• I did most of my training at UNISA. • I had subjects in web designing and computer integration to programming. • This helped a lot. • I'm capable of doing just about everything with my technology. • That said, the GDE can work harder to improve their workshops.

Figure 47: Different levels and Nature of training of participants

The table shows that Mr Khumo and Mr Zuva might have been exposed to the same training regime as the service providers appear to be the same and also they are the ones who installed the equipment in the schools. This might be the reason why Mr Khumo seems to be performing better than the others of similar experience.

Mr Sibeko although trained at a tertiary levels and expected to do well, he seemed to be affected by reasons other than training. Mr Ariel and Mr Johns are both self-taught but different outcomes, there must be other factors affecting their ICT integration. For Ariel self-teaching went horribly wrong with a mean rating of 1.75 and for Johns it went well with a rating of 3.25. This perhaps can be explained by their demographic data *(see section 1.5)*. Mr Johns was degreed in Physical Sciences whilst Mr Ariel was not and he was mainly a mechanical teacher but teaching Physical Science. Whilst the rest had some form of ICT training Ms Nomsa was (purely a Physical Science teacher) and only Mr Sibeko was a Natural Science teacher but teaching Physical Science – this might explain the result he got without ICT formal training.

Mr Sibeko's answer right at the bottom that GDE must work harder to improve their workshops indicates his frustration with the GDE workshops. Birman, Desimone, Porter and Garet (2000), Garet, Porter, Desimone, Birman and Yoon (2001), Lawless and Pellegrino (2007) and Royer (2002) have confidence in that expert educator improvement ought to be on-going and that 'one-shot sittings' are not productive.

Glazer, Hannafin, and Song (2005), Hinson, Laprairie and Cundiff (2005), Hinson, Laprairie and Heroman (2006) and Royer (2002) all contend that educator specialized improvement has to exceed the demanding seminar methodology and must become located inside the educators' operational circumstances, and move away from a transmission prototype (see Hoban, 2002) to a receptive distribution methodology, concentrating on on-going feedback, on-going improvement and uninterrupted upgrading.
The scenario depicted above shows that the varied competence of educators to use ICTs effectively for teaching and learning was perhaps a sign of more complex issues which need to be resolved to even out the playing field exhibited above.

5.3.2 Inclinations for transformation

Extracted from Main Questionnaire, Q4.1 (Appendix A9, A10)

4.1

Name	Describe how you rolled out the ICT Integration project in the Physical Science Department (focusing on things that were different to what you had planned)
Mr Ariel	The HOD and teachers in the know how seemed to have been leading
Mr Johns	• Identification of the right equipment and software. Some software was not adequate. • Per adjustment of software and equipment to meet requirement off the shelf materials were not adequate.
Ms Nomsa	• The school received laptops. • Signed for it. • Training was mostly done by Sangari on their I-box, but the rest one had to figure out. • Science educators help each other to get going.
Mr Khumo	
Mr Zuva	• Implementation of SMART boards in classes. • Implementation of tablets with e-boards • EPUBS – Not available yet – had to use PDF's • Implementation of learning management system. • Module – not function optimally: - Needs proper control and management. - The possibility of using alternative LMS's. - Cost of problem.
Mr Sibeko	• We first had a meeting to discuss how we were going to share the tablets and who will get interactive boards once funds are available. • We then set up a schedule to work with the tools and make turns. • We only used easy to learn software at the start that learners could use. • We slowly started to integrate more and more tools.

Figure 48: Showing the levels of different inclinations for transformation

The state of inclinations for transformation from the traditional methods of teaching to technological application seemed to have been mostly fraught with problems or suspicion of not being involved enough as there seemed to be "invisible" powers pulling the strings somewhere. Ms Nomsa mention the school "received laptops", Mr Johns talks of "some software not adequate" and Mr Ariel dismissively said that it was "HODs and "teachers in the know how". Only one teacher, Mr Sibeko was the only educator who mentions that they "first had a meeting to discuss". Ertmer (2001) and Hawley and Valli (1999) advocated that teachers should be invigorated to recognize their requirements where possible and what type of support they need. Mr Sibeko mentions that "they slowly started to integrate more and more," thus seemingly agreeing with Williams, Coles, Wilson, Richardson and Tuson (2000) who proposed that meagre assistance, a too rapid a pace and material burden contribute to ineffective application.

5.3.3 Attitudes and beliefs of Participants use of technology

Attitudes and beliefs are traits difficult to measure, but through observations and skilful interrogation one might get an idea or assumption on certain levels of attitudes. In the follow-up questionnaire

(A9), I asked the educators indirectly if they wanted ICT integration by asking if they thought this ICT integration project should continue. All six teachers agreed that it should continue, indicating their support of ICT integration.

Extracted from Main Questionnaire (Q1, Appendix A9, A10)….

1.

Pseudonym	Do you think this ICT Integration project should continue?
Mr Ariel	Yes
Mr Johns	Yes
Ms Nomsa	Yes
Mr Zuva	Yes
Mr Khumo	Yes
Mr Sibeko	Yes

Figure 49: Attitudes towards the continuation of ICT PROJECT

Contrary to what most literature said, all the participants indicated or agreed that ICT integration was the route to take. This I interpreted it as positive attitude towards ICT integration in their schools. This was a different scenario than that portrayed in literature (Rosen and Weil, 1995; Winnans and Brown, 1992; Dupagne and Krendl, 1992; Hadley and Sheingold, 1993) as cited in Mumtaz (2000) that indicate teachers as negative towards ICTs. Furthermore, educators' responses in the table below indicated the extent to which ICT integration had an impact on them:

Extracted from Main Questionnaire, Q5 (Appendix AA9, A10)

5.

Pseudonym	What impact has the ICT Integration project had on educator staff?
Mr Ariel	• Positive – advance in marks. • Negative – complains from staff that doesn't have it.
Mr Johns	• Increased self-esteem whereby the teacher is viewed as modern and in sync with current technological trends. • Will ensure that teachers are trendy and are using modern technology methods. • It will give teachers self-pride and eventually a better throughput. • Educators will be evaluated based on similar instruments not emotional peer-to senior evaluations.
Ms Nomsa	• Some have welcomed the initiatives especially the first beneficiaries. • Other members are of the view that those who use ICT are treated in high regard compared to those who do not.
Mr Zuva	• More effective teaching environment. • More interactive and collaborative work, but, this does take time.
Mr Khumo	• Most things are done electronically and we no longer carry many files. • An educator's file is in the laptop or USB.
Mr Sibeko	• At the moment none because it has not yet been properly integrated IMTD most schools. • Personally I use only ICT in lessons and I will not think of going back to the old ways. • I am giving higher quality lessons. • Learners are more focused on work and enjoy the lessons. • Due to my subject website, I collaborate with parents about homework & tests. • The learners get to see how the technology works & prepares them for the world. • Planning also became easier.

Figure 50: Showing the impact of ICT integration on Participants beliefs

In this project we had set to investigate apprehension about the use of technology by the educators in conjunction with their attitudes and beliefs. The educators regardless of age or gender they all held devices at home. Ms Nomsa had a Desk computer and a laptop for sole use and interestingly, Mr Sibeko had an array of devices to himself.

Extracted from Main Questionnaire 1.3 (Appendix A9, A10)

1.3 Devices at home with which you can access the internet

Devices	Mr Ariel	Mr Johns	Ms Nomsa	Mr Khumo	Mr Zuva	Mr Sibeko
Desktop Computer	Have sole use	Don't have access	Have sole use	Share with other people	Don't have access	Have sole use
Laptop	Have sole use (HP)	Have sole use	Have sole use	Have sole use	Have sole use	Have sole use
Tablet	Don't have access	Don't have access	Don't have access	Have sole use	Have sole use	Have sole use
Mobile Phone	Have sole use (Samsung)	Have sole use	Have sole use	Have sole use	Have sole use	Have sole use
Games console	Have sole use (PS2)	Don't have access	Don't have access	Don't have access	Don't have access	Have sole use
Other device (please specify)	Have sole use (Modem)	Don't have access	Don't have access	Don't have access	Don't have access	Have sole use: Projector DSTV PVR LED 3D TV LTE Connection

Figure 51: Participants own possessed ICT devices

The conclusive observation was that every educator had at least two free devices to him or herself confirming that the tendency to get acquainted and use of technology was more positive and therefore can safely say the educators in this project were less apprehensive towards the use of ICT devices than I assumed before the project. As an educator myself from a traditional background, I mostly plan my lessons at home or outside school premises and out of school hours. The assumption here was that these teachers might have tendencies to do the same. The analyses below seek to obtain an insight into how it compares to have an ICT lesson planning and the traditional lesson methods of planning.

The discussion on the next page offer responses from the participants on their view between the two major shifts in planning.

5.3.4 ICT versus Traditional Lesson planning

Extracted from Main Questionnaire 5 (A9, A10)

5.

Pseudonym	Is there any difference in the time that it took for you to prepare for a traditional lesson compared to now when you have integrated ICT into your teaching? Elaborate.
Mr Ariel	Yes, it takes more time now as PowerPoint takes time to iron out the problems and the time but once it is done you can use it and edit whenever.
Mr Johns	• Yes, the ICT lesson needs a list of planning and a good eye for detail, hence more time is needed. • Internet is full of some useful info so the teacher needs to be careful. • Arrangement of the lesson outcomes takes time. • In the traditional lesson, I would do a standard lesson plan and materials mostly include learner textbooks. Activities are already included.
Ms Nomsa	• The traditional lessons took time to prepare because you had to start from scratch. • These ICT lessons they are there from Sangari and approved by The Department of Education and therefore you require less time. • The best way is to go through them and know if the content is good and no misconceptions or will lead to misconceptions or total error.
Mr Zuva	• Initially setting-up e-lessons takes time, but resources are shared and easier. • This means that I might spend time preparing a lesson for Grade 9 NS but the lesson for Grade 10 Physical Science has been set for me. • In the long-term it saves time. • Lessons and charges are easier stirred for the future.
Mr Sibeko	• No, in fact it goes much faster as I type faster that I write and finding tools and materials is a click away. • Traditionally you have to page through lots of books to find any information or ides.

Figure 52 Comparison of Lesson Planning: Traditional vs ICT Integration (Appendix 10)

Three educators, Mr Ariel, Mr Johns and Mr Zuva are of the view that initial planning for ICT lessons take more time than traditional lessons. Their reasons ranges from PowerPoint needs time to iron out problems, need an eye for detail and selection of material from an all material internet resource. Mr Johns was of the opinion that in the traditional preparation, the books and activities are already there, one has no need to type or select from many materials. These have been done already But the other two teachers, Ms Nomsa felt that there was only little time required for one to prepare an ICT lesson because most of them have been prepared especially for service providers and Mr

Sibeko proffered that in the traditional approach one has to go page by page through a number of books looking for information thereby making it time consuming. Mr Khumo did not avail himself for the follow up questionnaire. Ethics states that questionnaires cannot be coerced into an interview and has the right to withdraw at any given time.

Educators teaching effectively with ICTs must have knowledge of which software and hardware to use for the benefit of their learners. The software are programs that allow users to work together with a computer, e.g. Computer Hope (2015) noted that although the hardware are the bodily components of electronic devices like computers, laptops, projectors, smart television, interactive whiteboards, motherboards etc. This research attempted to find out from educators the effect of these two variables on their ICT integration. The first aspect to be investigated dealt with the quality of the software and the second aspect explored the ease of use of both software and hardware.

5.3.5 Quality of software and hardware (Ease of use of both software and hardware)

The first thing this project wanted to establish in this new set up of the ICT integration was where the participants source their software from. The findings are that Mr Ariel sources from "personal or computer technicians", Mr Johns from "MathsScience marketing website", Ms Nomsa from "Sangari", Mr Zuva and Mr Khumo smartboards from Proline Intel and Mr Sibeko does "pay for his software". There was sourcing from several service providers and non-service providers, it was basically free for all.

The information on my notes before the commencement of the project indicates that the hardware Mr Ariel was given by 'Imperial", Mr Johns by 'Sasol initiative", Ms Nomsa by "Sangari South Africa", Mr Zuva by Paramount, GDE, and its SGB, Mr Sibeko partly himself, SGB and GDE and lastly Mr Khumo gets from the GDE. It was also a variegated type of sourcing from several role players in the market. The ease of use of both software and hardware was a matter of importance to the research project:

The ease of use of both software and hardware was a matter to the participants as Mr Ariel reports that he has to "experiment", Mr Johns seemed comfortable using an array of software, Ms Nomsa relies basically on the I-box, Mr Zuva uses integrated software that comes with the hardware and Mr Sibeko basically uses from tablets, Bluetooth, and smartboard and he said "he can do anything" with ICTs.

Extracted from Initial Questionnaire Q3 (Appendix A3, A4)

3.

Pseudonym	Where do you source the software or technologies for teaching Mechanics?
Mr Ariel	Personal or Computer Technicians
Mr Johns	• Ms Package came standard with the computer. • YouTube videos are downloaded from the internet. • Extra software is downloaded from the internet. • Maths & Science Marketing website.
Ms Nomsa	• Sangari South Africa I-box contains all the materials. • PowerPoint, Phet Animations, downloaded YouTube videos, Graphic Instruments and Evaluation Techniques.
Mr Zuva	• SMART Notebooks – cones with SMARTBOARD. • Phet simulations available on internet – Google • Colorado University Phet simulations. • DesignMate 3D software from Edu board. • Intel skool simulations
Mr Sibeko	• At the moment I pay for software myself or I search the net for appropriate tools that's free.

Figure 53: Software and Hardware

These responses seem to indicate that participants move from finding it difficult to use to simpler depending on the different gadgets available. After examining the issue of software and hardware the next variable was to enter into the school terrain itself to obtain an insight of how the integration process was conceived by those in context. The following different responses were proffered as below:

Extracted from Initial Questionnaire Q2 (Appendix A3, A4)

2.

Pseudonym	Which software do use and how do you identify this type of software for the purpose of teaching Mechanics if not part of standard tablet package?
Mr Ariel	• Auto Cad • PowerPoint • Java • Need to experiment and see what works for individuals
Mr Johns	• I use the following software: (a) PowerPoint Presentations to quickly give information. (b) Microsoft Word – to create texts and worksheets. (c) YouTube videos to ensure that learners see what other experiments/lists have done on the subject topic. (d) Animation software much as PHET. (e) Microsoft Excel: for data manipulation and drawing of graphs /charts. (f) Maths and Science Marketing website.
Ms Nomsa	• I use the Sangari South Africa, I-Box recommended by the Department of Education. • This software has got pre-planned. • Lessons arranged to the Caps document. • The i-Box has video content, Phet Animations and films to do with the topic in question. • The tablets delivered had no teaching material for educators.
Mr Zuva	• SMART Notebook. • Phet simulations • DesignMate 3D Software • Intel skool simulations • LearnTL
Mr Sibeko	• Word processing software which was included in the tablet package helps learners to type answers to questions and using Bluetooth can send to teachers computer and displayed on classroom screen. • I downloaded some software online like google maps to explore the earth, scholarly software to share questions and answers with learners in real time on the net. • Mostly the current tablet project is not working well. • The GDE should open up software options to download for free to help with most subject matter.

Figure 54: Shows the software and hardware used by participants

5.3.6 *The rationale of implementing ICT integration*

Extracted from Initial Questionnaire Q2 (Appendix A3, A4)

2.2

Name	**Why did your school or Science Department decide to implement the ICT Integration project?**
Mr Ariel	It was recommended.
Mr Johns	• Learners are more captivated. • Lessons are made exciting. • Lessons can be replaced, stored and modified. • An information back-up/bank is created. • Educator absence would not cause a lot of disruptions.
Ms Nomsa	• They were adopted by Sasol Inzalo as a school of focused learning. • ICT was one of the changes that educators had to adapt as part of the sponsorship package. • The government then supports us with computers as part of the Gauteng online project.
Mr Khumo	We are a pilot project by the MEC.
Mr Zuva	• Possibility to do simulations for learners. • Daily testing of learners is made easier. • Opportunity for learners to watch videos/animations explaining concepts.
Mr Sibeko	• To enhance the teaching and learning. • Improve efficiency of the planning. • Helping learners understand the work better.

Figure 55: Rationale of implementing ICT integration

From all the sites, the information obtained reveal that ICT was conceived differently as one was an adoption by a private player, another pilot project of the GDE MEC and another to track the absenteeism of the educators as a management tool for administration and efficiency in planning. This means that a lot of misconceptions exist on the meaning and purpose of ICT integration in the science classroom even in the thought process of the planners and motivators of the ICT project.

Mr Zuva seemed to match some of the good pedagogical intentions of implementing ICT integration in the science classroom as he mentions the possibility of simulating the content to learners, assessing learners and developing concepts.

This was followed by Mr Johns who precisely described that his intentions of ICT integration was to motivate learners, having exciting lessons, easy storage and retrieval of lessons for continuous use. Lastly he wanted ICT integration to monitor educator's absenteeism as part of school management and administration.

Mr Sibeko was of the notion of planning efficiency and help learners understand their work better. He seems to think in more broad terms, thinking of the whole institutional set-up improvement plan...

In contrast, Mr Khumo does it because the MEC or the higher authority has prescribed it and this seems to be the same notion with Ms Nomsa who got it through a private sponsor and Mr Ariel who just mentioned that it was “recommended”. As Dlamini (2014) detailed, pedagogical ICT integration does not contribute to the one-size-fits-all framework. The findings of the project agree with this claim because on investigating as to what was the aim for initially starting the project one can perceive from the responses that every participant had a different notion. Now, because the aims and objectives of setting ICT integration were so different in scope, this project set out to “unpack” the dynamics that goes inside the school involved in such a project by finding out from these participants what would be the obstacles or enhancement factors.

The first port of call gleaned from some participant’s responses was to examine the situation at operational levels at the high schools themselves. This operational process is directed by the school administration. Therefore our focus was to obtain insight into the role of Principals and School Management Team. As shown below and the analysis that follows.

5.3.7 The role of Principal and School Management Team

Extracted from Follow-up Questionnaire (Q4 A11 and12)

4.

Pseudonym	Are there any factors that may help or hinder the continuation?
Mr Ariel	To hinder, finance as well as SMT.
Mr Johns	• For continuation we will need. • Rapid resolution of problems encountered at implementation and evaluation stages. • Do? problems, this will remove teacher frustration. • ICT Champions should be readily accessible and be well trained to resolve any issues. • Educators should be allowed and unlimited to use other resources for content environment whereby each teacher will have some ownership of content.
Ms Nomsa	• The principal & SMT lack of knowledge of what is required to plan forward. • Parent’s participation being how. • Lack of enthusiasm from the teachers. • Incentives • Making CAPS ICT compliant & examinable.
Mr Zuva	• Limited internet access to teachers and learners. • Limited control from teacher on learners tablets. • Tablets need to be blocked for teaching purposes during certain times. • Help better Learning Management Systems/ classroom management systems.
Mr Khumo	
Mr Sibeko	• Lack of qualified teachers to teach using ICT in schools. • Lack of computers/tablets because of funds.

	• Lack of electricity in many areas and the current energy problems of SA. • Burglary keeping ICT safe in many schools is expensive and crime is high. • Teachers fear using ICT and have no confidence. • Anytime, anywhere access to teaching & learning materials. • Collaboration with like-minded people all over the world. • Can help prepare learners for a working world with tech. • Greater efficiency throughout the school. • Greater flexibility in when & where task are carried out. • Easier planning & preparation of lessons & support materials.

Figure 56: Principal and school management contextual variable in ICT integration

In terms of the role of Principal and School Management Team the educators cited firstly the funding regime governing the ICT integration in terms of teacher motivations, obtaining of hardware and software and learning materials. Literature shows the three major factors involved in these 'accomplished' educator' achievement to ICT integration were educator motivation and dedication to their learners' education and to their own improvement as educators; the backing they experienced in their schools and availability to adequate amounts of technology Mumtaz (2000). The participants felt that if the administration of the school does not allocate enough funds to the smooth running of the ICT integration project then the whole process would stall. They are of the perception that an incentive model ought to be worked out to reward educators who become ICT integration compliant otherwise others would not value the change required.

Secondly the participants felt that the School Management Team (SMT) from the Principals to the HODs had *"lack knowledge of what was required on ICT to plan ahead"*. Ms Nomsa was of the view that since this was a new project she felt it was going "slow" because the principals and school management team members were on the same level of ICT integration with their subordinates or even below hence they had no planning skills of the nature required in ICT integration.

Thirdly, they mentioned parental involvement. The parental participation was envisaged to be low probably because the parents themselves like their educators and SMT's who did not have enough knowledge on the issues of ICT integration.

Fourthly, they felt that CAPS ought to be ICT compliant. The participants wished if there was a mechanism to control Tablet usage once in the hands of learners, mainly to avoid abuse of the internet or distracting them from paying attention. Mr Zuva sighted better learning management systems and classroom management systems as vital. Finally, Mr Sibeko lamented the lack of teachers with the know-how of how to integrate ICTs in their teaching. This leads to the issue of assistance received or anticipated support.

5.3.8 Leadership, support and collegiality in the school

Support for the ICT integration and collegiality (meaning a working environment where responsibility was shared equally among colleagues) are very important. The participants felt that for this to happen, all departments were supposed to be integrated, data banks were to be created for all the subjects, specific training for subject areas and prioritization of the scarce subjects. They felt that the SMT was supposed to do the content selection and acquire user friendly software and hardware. In literature, Richardson (2003) noted the significance of an external source as a helper / staff developer.

Extracted from Follow-up Questionnaire (Q2, A11 and A12)

2.

Pseudonym	If you answered YES to 1, how do you envisage it will develop?
Mr Ariel	For all departments to be integrated into each other.
Mr Johns	• Should be inclusive so to cater for the whole school. • Data banks should be created for each subject. • Specific training for each subject so to give a better more focused use of ICT.
Ms Nomsa	• Help must be rendered where it is needed most – English / Afrikaans / Language areas. • Then technical and other subjects in order of priority. • Training must be given according to 1. • H.O.D. must go for content selection and materials they think best for their schools. • Schools must identify software and hardware negotiated /identified by the parent body / teachers / SMT & DBE.
Mr Zuva	• More user friend interactive content. • More integrated content in lessons – questions videos. • More content being used online. • More support out of classroom context.
Mr Khumo	
Mr Sibeko	• The future of ICT is not to replace teachers ICT is about access, anywhere learning and collaboration with others, both locally and globally. • Teaching and learning is social and schools in the future and with proper ICT could have a tradition of sharing and brainstorming ideas. • This will make learning faster and easier. • The classrooms of the future will have fast internet connections with wireless connection. • Learners can instantly share ideas with educators.

Figure 57: Leadership, support and collegiality in the school

My findings indicate that participants have mixed feelings in terms of the implementation of ICT integration as all participants mentioned that, this project was supposed to cater for the whole school. It might be that there was a perception that only science and mathematics are important.

There seems to be a realization that some of the hardware and software being used do not meet certain standards and most participants advocated for more user friendly interactive content, request that HOD must be trained to identify proper software and hardware, concurring with the idea that the SMT seem to lack ICT integration management skills. From this stage, this leads the research project to probe into the classroom context and activities:

5.3.9 Classroom life and Activities

Extracted from Follow-up Questionnaire (Q6, A11and A12)

6.

Pseudonym	What impact has the ICT Integration project had on implementation of Caps Physical Science in your school?
Mr Ariel	Not sure
Mr Johns	• It has made teaching of waves, atomic theory, motion (mechanics) much easier for the teacher. • The learners were able to identify with abstract concepts.
Ms Nomsa	• Books – e-Books like siyavula easily accessible. • Past exam papers available. • Availability of already made lessons available.
Mr Zuva	• CAPS documentation instantly available on screen in front of you. • Better CAPS implementation through ease to copy and paste from CAPS documentation and resources.
Mr Khumo	• Most of our books are loaded on the SMART board. • You will never run out of space when you use the SMART notebook. • No PDNE anymore. • Textbooks loaded on the board are all CAPS aligned.
Mr Sibeko	• ICT makes it much easier to follow the CAPS Curriculum, but the ICT project that is current in working is not doing as much as it could. • ICT should be placed in the hands of qualified teachers that can plan and integrate it.

Figure 58: shows the contextual factors affecting classroom life and Activities

The science classroom and the activities taking place there constitute the most important contextual variable regarding why ICT integration was of concern to this study. One educator, Mr Ariel observed that he was not sure if ICT integration project has had any impact in his sight. Mr Johns recognize that the teaching of motion (a greater part of the mechanics) could now be taught easily. Ms Nomsa noted the presence of e-books and past exams. Mr Zuva mentions that CAPS documents are easily available as well as their associated materials. Mr Khumo commented that books are loaded on the smartboard and there was no need for pen or chalk and finally Mr Sibeko agrees that ICT makes it "much easier to follow a CAPS curriculum" but this project "should be placed in the hands of qualified teachers that can plan and integrate it". This last statement requires that we look at the government policy as the last contextual variable of this project.

5.3.10 Provincial and national polices commitment to professional ICT learning and teaching

Extracted from Follow-up Questionnaire (Q5.2, App A11 and A12)

5.2

Name	**What would you do differently in the Physical Science Department if you were starting to implement this ICT Integration project now?**
Mr Ariel	I would go for more training and see which program best suite our school.
Mr Johns	• Get everyone's involvement. • It should not be made to seem like the project is parked down to us by management. • Take all suggestions with all the respect they deserve.
Ms Nomsa	• Train the Head of Department. • Train teachers on the role of ICT usage in P.S. • Call/invite ICT subject specialist and service providers for staff development.
Mr Khumo	
Mr Zuva	• More effective Learning Management System to be used. • Gradual integration from projectors – Smartboards & tablet use by learners.
Mr Sibeko	• Nothing, there will always be challenges and you deal with wit as it pops up. • It was a good learning experience.

Figure 59: National and Provincial commitment to professional ICT learning and teaching

The South African White Paper on e-Education clarifies the kind of education anticipated, the degree of ICT knowledge that are a prerequisite, and the sort of school that was necessary for the fruitful ICT establishment (DoE, 2004). In 2007, the Department of Education distributed Recommendations for Educator Preparation and Specialized Improvement in ICT (DoE, 2007) which recognizes the necessity for Professional Teacher Development (PTD). This paper noted the importance of the educator in the operation procedure, and the necessity for educator preparation in order to institute the ICT understanding, abilities, standards and approaches. Nevertheless, it offers few facts on how educators and schools are anticipated to basically incorporate or make use of ICT inside the South African framework. The participants mentioned policy or lack of it. They need School Management Team’s trained, they themselves need training, they require coordination and assistance that can only be given by a higher authority than them and schools. Looking at the variables mentioned below did require provincial and national polices commitment to professional ICT learning and teaching.

5.4 Inferences concerning the TPACK of educators and contextual variables in this project

In evaluating the analysis of responses from firstly category A, curriculum goals and technologies (curriculum-based technology use) educators exhibited a developing and some a standard level rating. It can be deduced that this might be because the curriculum goals are spelled out in the National Curriculum Statement and relatively easy to link technologies, especially if that has been done already for one by the service providers.

Secondly, technology selection (Compatibility with curriculum goals and instructional strategies) it was clearly shown that the educators, although they could link the selection of technology based on curriculum goals they had difficulties with aligning them to instructional strategies. Their rating in this category was mainly served by their strength to select in line with curriculum goals, but their inability to align with instructional strategies proved to be their undoing in most cases.

Thirdly, instructional strategies and technologies (Using technology in teaching/ learning) the educators exhibited low skills in this category. Most educators do not arrange their lessons with different strategies. Educators can start a lesson with a PowerPoint and end with the same PowerPoint. Only two educators explained their strategies and corresponding technologies well, but the rest struggled. Literature shows that in the topic specific measurements of Physical Sciences, conceptual teaching strategies are the most difficult (Mavhunga, 2012).

Lastly, Fit (Content, pedagogy and technology together) proved the most difficulty of all the categories of the TPACK constructs. This might be that the educators had a challenge combining the three together. The first problem identified was that of educators teaching physical science which was not their area of specialty. The Education for All (EFA) 2000 assessment (2005) also stated that 84% of science educators professionally qualified, only 42% was competent to teach Physical

Sciences meaning most have problems to teach the subject hence low capability when it comes to the Fit component

Furthermore conceptual teaching strategies in Mechanics are a problem. Teachers in the study did not seem to display that they understood what conceptual teaching was and the relevant instructional strategies. Teaching Mechanics follow three fundamental conceptual teaching strategies in the Physical Sciences: Procedural Knowledge Building, Conceptual Knowledge Building and Knowledge Expression. Among most educators I could not distinguish when there was a procedure being developed or when a concept was being built. Therefore, this combination has to be viewed in tandem with the context they operate.

Educators as projected by their responses work and operate within a given context. These contexts affect the trajectory of their TPACK development. The educators who are at varying levels of competence in implementing the ICT project reported that they teach under a shortage of Physical Science educators. They reported that the inclination for transformation from traditional teaching to technological teaching was not well coordinated from top to bottom, especially at the bottom where implementers are located. Although attitudes and beliefs on the use of technology are positive, they are confronted by lack of poor training. The initial time planning constraints, sourcing of software and hardware and obtaining good quality software and hardware has resulted in poor teaching standards.

The poor standards have also been exacerbated by the role of Principals and school management teams, compromised leadership, support and collegiality in their school. In addition, the provincial and national policies commitment to professional ICT learning and teaching was inconsistent. Batchelor (2014) proffered that ICT incorporation was viewed as a wicked problem within the education circles in South Africa as it was required at policy level, but ignored at functioning level and there was existence of numerous role actors not well harmonized with seemingly concealed agendas looking for the fast fix, with policies determined by an idealistic viewpoint of current research programs, limiting theory construction, overlaying Eurocentric study viewpoints in emerging situations, and finally exposed to speedy modifications in the field with possibilities of modification before they can be judged suitable results.

Overall, the participants got a rating of 3 i.e. developing TPACK *(see TPACK rubric)* this was because of the fact that they provided good quality responses in other categories. Their weaknesses in one aspect of ICT integration was balanced by their strength in another aspect. The above responses provide further evidence that the TPACK instrument could measure the differences in qualities of TPACK of Physical Science participants and hence it was valid.

5.5 Conclusion remarks

The narrative aspect of the ICT application in the Mechanics lesson exposed a number of factors affecting successful integration. The quality of responses in each category of TPACK traits corroborated a deficient narrative in the Fit classification trait. Some participants relied on the content material integrated in the hardware but during class observation some concepts were conceptually wrong. Others were of the idea that any lesson written electronically is ICT integrated oblivious to the fact that there are technological instructional strategies which are mainly subject and topic specific in sciences that allow a lesson to be classified as an ICT integrated Mechanics lesson.

But also the same narrative revealed the strengths of educators in their ability to show case the teacher knowledge in technology selection and curriculum goals linked to technologies.

Lastly the qualitative analysis revealed a plethora of contextual variables ranging from different levels of competence of participants in ICT integration with some very low and others very high. The educators cited that their management teams were not prepared to plan and manage technology integration. They themselves received a variegated amount of training and sometimes no training but depending on trial and error techniques among others.

5.6 Projection to the next chapter

The next chapter was the final chapter which proffers discussions of the findings, implication of the results and conclusions of this research project on ICT integration.

CHAPTER 6

Discussion of findings, implication of results and conclusions

This chapter offered a brief summary of how the project was carried out and also discussed the findings in relation to the research questions for this project. Associated literature was reviewed and implications of the findings presented. Conclusions, recommendations and lastly limitations of the research project were argued.

6.1 Overview

Firstly, the initiatives by the GDE to provide tablets to government funded schools, in addition to the computers supplied under another project called the GOL, at a huge cost running into millions of Rands was the main motivation that led me to undertake the study concerning ICT integration, in specific its state of inclusion in the teaching of the subject Physical Sciences. Secondly, Physical Sciences are considered as one of the most difficult subjects in the South African school system, according to the records issued by the Department of Basic Education (DBE, 2012). Lastly, learner performance in the topic of Mechanics (Work and Energy) in the Grade 12 examination has been found to be particularly poor in the report of NSC (DBE, 2012).

Ornek, Robison and Haugan, (2008) are of the view that learners consider Physics concepts as difficult and abstract as they should be represented as experiments, formulas, calculations, graphs and conceptual explanations that should be transformed among them. For this reason, learners tend to perform poorly in this topic. Literature indicates that the learners in different countries hold a number of misconceptions about the Mechanics topic starting from grade 10 when it was first introduced in secondary school learning. This suggested the need to establish how physical science teachers can alternatively handle the topic Mechanics using ICTs and unpack this topic so that it was understood by their learners.

For this reason, Technological Pedagogical Content Knowledge theoretical construct (TPACK) guided this research project. The TPACK rubric was used as a tool to measure how effectively educators teach using ICTs. The rubric was composed of four components namely: (i) Curriculum Goals and Technologies (Curriculum-based technology use), (ii) Technology Selection(s) (Compatibility with curriculum goals and instructional strategies), (iii) Instructional Strategies and

Technologies (Using technology in teaching/ learning), (iv) Fit (Content, pedagogy and technology together). It was believed that it was through these four components of TPACK that one was be able to measure the extent of how effectively the selected participants use ICTs to alternatively transform the abstract topic of Mechanics to a level understood by the learners (Harris, Grandgenett and Hofer, 2011). It was through the TPACK instruments: questionnaire, questionnaire and observations schedules that the four components of TPACK were assessed and analyzed.

6.2 Reflections on the study

Firstly, correspondence was entered to with specialists who subscribe to TPACK theoretical construct, courtesy of the Researchgate membership. Conference papers on the construct, journal articles and the exchange of ideas of how such studies are carried out was proffered. Secondly, permission was sought to use the materials and these have been indicated. Thirdly, the selection of materials that would address the key issues was done. Fourthly, some materials were used as they were from the original authors and others were adapted to suit our context and these are indicated too. When I was done, I presented the finished proposal to the supervisor.

I recall one of the comments from the supervisor which was "You must write the questions and provide the answers". This was strange to me but as I proceeded to take the instruction, I discovered that the "wording", "length", "time-frame" and "scope or depth" of the instruments had to be adjusted. I remembered the module on Language and Communication (Oyoo, 2009 and 2011) that words if not used carefully one might lose your participants. The power of the TPACK tool lies in the fact that it was adapted for the South African context. The teachers' comments are captured by the TPACK tools. The additional strength of these tools was that it was left semi-structured to solicit more comments from the respondents. The teachers were to add more comments as it had built-in spaces.

The significance of this project was that the TPACK rubric has been adapted by providing measures that can be quantified and thus allowing the extent of TPACK to be statistically determined (using the Rasch Statistical Model) to a certain degree of consistency as measured by the Cronbach Alpha. One was able to determine if the participant was on standard, developing, elementary or inadequate. Furthermore each trait enabling or hindering was determined. This was unique to this study.

The tool was targeting practicing educators who had taught participants in high schools that were undergoing the GDE ICT project implementation and who were using ICTs to teach the topic of Mechanics at grade 10 when this topic was being introduced in the matric system. Since South Africa has a shortage of Physical Science teachers, getting these participants was a problem. Thanks to the Teacher Upfront organization that helped me get access to the principals and the participants who had a story to tell of their ICT integration. The organizational structure of the project (from principals, SGB members, HODs and the participants) was all agreed courtesy to the facilitation afforded by Teacher Upfront. It made my research project planning a lot more easy. The administration of instruments or tools was facilitated much more easily.

The use of Mixed Methods allowed me to comprehend better the nature of different knowledges involved in Technological Pedagogical Content Knowledge. The data was analyzed both qualitatively and quantitatively. The use of the Rasch statistical model helped to support the validity and reliability of the instruments. The Rasch model gave the reliability indices of both the persons taking the test and the items. It also provided the internal consistency of the test as measured by Cronbach's KR-20 Alpha.

6.3 Summary

This project set out to determine the extent of effective use of ICTs for pedagogical and technological use in the teaching of the Grade 10 Physical Sciences topic of Mechanics by six educators in three high schools in Gauteng province, South Africa. The project sought to explore the integration of ICT in the teaching of Mechanics and the influence of context on this integration. This was important research since it can inform educators on strategies for the effective use of ICTs in the Physical Sciences. It allows an exploration of component per component diagnosing where educators may have weaknesses and it also illuminates the areas of application where educators are strong.

6.4 Discussions of findings

6.4.1 The extent of integration of ICT in the teaching of Mechanics.

The first research question investigated the extent of integration of ICT in the teaching of Mechanics. Responses of educators showed that their TPACK was still developing. This might be because this was a new pedagogical tool being rolled out because not only the South African government was advocating for ICT integration but many others (Greenhow and Robelia, 2009; Common Core State Standards Initiative, 2010 and Jonassen, Howland, Marra, and Crismond, 2008).

Although educators claimed to have spent various years using ICTs in their teaching, most of them seemed to have struggled to pedagogically and conceptually articulate themselves on this topic. This was in agreement with the results of Crompton (2015) on her assessment of ICT educator preparation in the USA in which she stated that many teachers are not effectively incorporating technology into their teaching and learning.

The findings show that most of the participants struggled with instructional strategies when used with technology for effective teaching and learning and thereby not performing highly in the subsequent and final category of Fit (Content, Pedagogy and Technology combined together). Crompton (2015) attributes this to the lack of success to achieve the dynamic interaction between the mastery of the subject content, pedagogical techniques and technological affordances.

The participants showed a promising ability in the skill of selection of technologies for teaching and learning and aligning Curriculum goals to technology in the topic of Mechanics in Physical Sciences. Even when assessed in a topic of Mechanics they chose independently from the one of Mechanics, these two class categories were responded to very well compare to the instructional strategies and Fit (Content, Pedagogy and Technology combined together). Ndongfack (2015) attributes this to the notion that their professional development programs are focused on fostering their computer knowledge as a stand-alone skill. Their poor performance in instructional strategies and Fit (Content, Pedagogy and Technology combined together) stems from the fact that the training programmes do not lay emphasis on these constructs.

The Rasch model as used in this project summarizes completely participants standing on variables such as their ability in Technology selection(s) or instructional strategies i.e. from the highest ability to the lowest ability (Bond and Fox, 2001). The results of the statistical analysis as well as the qualitative analysis of responses by participants shows that the participants in this project struggled a lot in the Fit (Content, Pedagogy and Technology combined together) category and found Technology Selection(s) category the most easily.

The Rasch scores confirmed that responses from most physical science teachers struggled with the Fit category and instructional teaching strategy component of TPACK. The reason could be the fact that in order for the participant to answer the questions in this category, s/he has to draw from all other knowledge components of TPACK. S/he should pull the entire knowledge component together for him or her to be able to answer the questions from the Fit and conceptual teaching strategy category. From the item map, it was clear that all the participants did not give good quality answers to all questions. The majority of the participants were not able to answer the questions satisfactorily and some who attempted were not even coherent.

It is interesting to note that Mr Zuva and Mr Johns demonstrated an overall better quality of Technological Pedagogical Content Knowledge as measured by the TPACK rubric in all the categories including the category items in the Fit and conceptual teaching strategies. On the other side Mr Ariel struggled in all the test categories. This confirms the theoretical postulations that a person with higher ability was able to answer difficult test items. This indicates the validity of the TPACK rubric since the theory agrees with empirical evidence (statistically validity) from the Rasch model. But the TPACK construct acknowledges the operational synergy with contexts.

6.4.2 The contextual variables affecting ICT integration in South African High Schools.

The second research question was dealing with contexts that affect the participants ICT integration in Physical Sciences especially when the topic of Mechanics was being taught in their high schools. Rosenberg and Koehler (2015) stated that context was an important aspect of educational research and the technological pedagogical content knowledge (TPACK) framework, but was often missing from TPACK research, or its specific meaning was not clear. In this research project all efforts and energy has been devoted to fundamentally interrogate contexts affecting the ICT integration study in this research project.

The most outstanding variables were to do with the manner of implementation. Most participants seemed to have varied aims, objectives or intentions regarding the ICT integration as a whole in their school and more specifically in the science department. This was in agreement with Dlamini (2014) that ICT integration was not a one size fit all process. Their answers ranged from this was the "MEC's project", class management, school management, monitoring educators and to that of improving results in Mathematics and Science.

The Planning process at school level left a lot to be desired. Only one participant mentioned that there were briefed and had meetings about the impending ICT integration. The rest made no mention of being briefed or when being done it was from "top to bottom" approach regardless if it was government or private players involved. They felt it was like being imposed on them.
Crompton (2015) stated that to ensure educators use technology effectively, it was essential that training was provided. Training was almost as sporadic as it was haphazard in all the three high schools. Different participants reported from being self-taught to being sent from to various service providers for adhoc training *(as early as 2015 when implementation began)*. The service providers varied from specialized companies producing the equipment to unknown entities whose consistency with pedagogy requirements could not be ascertained.

Hardware quality and quantity distribution was chaotic as shortages and withdrawals became order of the day. Participants reported that Gauteng online facility stopped working, interactive whiteboards and smart televisions were not enough and only two per school I-boxes were issued. In other instances, when the tablets were introduced, within a few months they were withdrawn and reasons cited included that they were going for security upgrades. Eventually there was no further communication about the tablets and they disappeared for good and never returned.

Software quality and quantity availability was limited. Participants using smart televisions seemed to have recent e-books, papers, animations and more artifacts than those using I-boxes, laptop and projector only. These educators reported that CAPS aligned software was limited and where other version where available they were not meeting South African contexts. Planning was not as fluid to everyone as one would like to see.

Initial planning of ICT integration for teaching purposes was not well managed at all schools under this project and within their science departments. This was occurring at individual levels. This was noted when 50% of the participants mentioned that initial planning in ICT integration took long and the other 50% were of the view that traditional planning took longer and never mentioned what as departments or school was the policy on planning, it shows uncoordinated planning. . If the argument was done by the participants from the same school it indicated that there was no management planning in regard to both methods of planning in that department. If it was from different schools, it showed me how widespread the ICT lesson planning mismanagement was. Both variations manifested among the schools. I concluded for this project that ICT integration lesson planning was mostly “show me how much you can do” type of approach.

Leadership at school level was low. The Principals of these schools were reported to be very enthusiastic about ICT integration but the visions were as chaotic as reported above because they had no formal management on the tools of this new trade- ICT integration except in one school. In the science departments, the Head of Departments had no management training on ICT integration and most cases the subordinates knew more than the “boss”. Most members of the school management team were as clueless as the HODs. The educators who knew assumed or gained an extra self-esteem. This brought its own set of “compromises” – positives and negatives on working relationships. The parents’ participation was recorded as low. Rosenberg and Koehler (2015) further stated that when context was included, classroom and school factors and those related to teachers were more likely to be included than those related to students and society.

Leadership at government and provincial level commitment to professional ICT learning and teaching was not well defined at operational level of the policy. One participant noted that CAPS was ICT non-compliant and there are no measures to assess it. Therefore there was no need to “stress”. Other participants alluded to lack of remuneration structure for those who equip themselves with ICT integration skills. The whole buck stops with the government.

At provincial level participants are of the opinion that ICT learning and teaching was a subjective matter i.e. every MEC (read politician) who comes (as education head) brings his or her own philosophy in ICT integration which ends with his or her term. There was no consistency on policy implementation regarding professional ICT learning and teaching. Participants cited the defunct Gauteng Online Project which they allege underwent a silent death. Other participants claim that this project was likely to undergo another silent death if the incumbent goes. Therefore the educators’ extent of pedagogical integration was still developing and affected by a plethora of contextual variables that can be fixed in the short term and the long term if the government becomes consistent.

6.5 Conclusions and implications

Recently, there has been interest in Africa (TPACK Newsletter, Issue #25: October 2015) on the usage of the theoretical construct TPACK with examples of teacher education colleges in Tanzania being equipped with computers to prepare teachers who can integrate technology in teaching (Kafyulilo, Fisser, Pieters, and Voogt, 2015) and in Cameroon primary school curriculum adopting TPACK as a framework for describing the knowledge and skills that pre-service teachers need to develop in order to effectively integrate technology in science and mathematics teaching (Ndongfack, 2015).

Others have been investigating the contextual factors influencing teachers' use of technology as well as teachers' Technological Pedagogical Content Knowledge (TPACK) levels (Owusu, Conner and Astall, 2015). This emphasis on TPACK was premised on the belief that a high level of TPACK can make a considerable impact on the quality of teaching delivered by the teachers to learners and consequently on the quality of learning experience in most classroom environments (Park et al., 2011).

This study sought to determine the extent of pedagogical use of ICTs of physical science teachers in these three approved high schools in Gauteng. The instruments and the adapted TPACK rubric showed that they could be useful in the sense that they can be readily administered as the validity was now known. Also the findings suggests that the aforementioned instruments and the adapted TPACK rubric, has a potential to provide dependable information about the extent of technological pedagogical content knowledge of practicing teachers in the teaching of Mechanics as it has been statistically found to be valid and reliable. Therefore, science education programmes or teacher intervention programs aimed at improving the teaching of Mechanics may use the adapted TPACK rubric as an ICT integration assessing teaching tool for both practicing and pre-service educators.

The practicing physical science teachers in the study showed that they have a developing TPACK rating in Mechanics. This provide a clue as to why learners in grade 12 end up performing poorly in the matriculation examination on this topic since the basics have been lost in grade 10 teaching. This suggests that teachers may not be presenting this topic with suitable instructional strategies (Conceptual Teaching Strategy) in conjunction with technology. The teacher content, pedagogy, technology combined knowledge was not good. This implies that these teachers may be resorting to algorithms and facts (Kind, 2009). Teachers with poor quality or limited TPACK might not be exposing learners to strategies that promote motivation and conceptual understanding of the topic.
Other factors such as self-teaching was shown to have the potential of being disastrous if used in a subject that one was not well grounded, experience in teaching the subject and knowledge of learners

and the context would come into play. Also established in this study was that attitude of the participants towards ICT integration showed a positive thrust as compared to what literature has proffered. Research has shown that attitudes and beliefs are the precursor of change to TPACK in addition to teaching experience.

6.6 Recommendations

In light of the findings above, the following recommendations are made

6.6.1 Large scale application of TPACK instrument to educators incorporating ICTs

The research project recommends that the instruments and TPACK rubric should be administered on a larger scale to other practicing teachers who are integrating ICTs within the Gauteng Province and in other provinces in South Africa. This did allow a proper picture to be created on the state of ICT integration and to further roll out the program informed by the context. This can be applied to the rest of the continent to obtain an African context.

6.6.2 Integration of TPACK instrument to pre-service educators

The research project further recommends that this instrument be used to further the extent of TPACK of pre-service teachers in Physical Science. I would have wanted to measure the TPACK of recent graduates entering the profession. The current study targeted teachers who were claiming to have previous teaching experience at integrating ICTs.

6.6.3 Integration of TPACK instrument as a preparation tool in educator staff development

Teacher intervention programmes or workshops in Physical Science should not only concentrate on content knowledge but the manner in which content was being delivered. However, Professional Development often lacks any form of assessment making it difficult to understand what participants really learned (Saldana, 2015). This adapted TPACK rubric allows assessment and enables managers to obtain data on areas where educators need support rather than the guessing game going on at the present moment.

6.7 Information for future Research project

The adapted TPACK rubric might be a valuable tool to be incorporated into these teacher programmes or workshops so as to check the physical science teachers' effective ways of teaching with ICTs and to reason among the components of TPACK. We have seen in this project that having software and hardware does not necessarily imply that the teachers are able to handle the topic very well in classrooms. In short, the study revealed that though the teachers knew about ICTs most of them had some deficiency in TPACK because most of expected attributes of TPACK are not well developed but still developing. These intervention programmes or workshops should therefore focus on improving instructional teaching strategies and technologies and Fit (content, pedagogy, technology combined) which have proved to be difficult for most of the teachers in this research project.

A valuable extension of this study would be to explore the relationship between the measured extent of teacher's technological pedagogical content knowledge, their content knowledge and topic specific pedagogical content knowledge.

6.8 Limitations of the Research project

In the original design of the study I had intended to audiotape an initial (structured) questionnaire and follow-up (unstructured) questionnaires. This could have helped me to categorically capture the decisive moments such as apprehensions, facial expressions, stammering's and all the necessary registers of the discourse. As stated earlier on, most educators were of the view that they had time constraints. They suggested that the interviews be converted to questionnaires. Therefore the present structure ended with initial questionnaire (pedagogical approaches), questionnaire (contexts), observations (capture lesson experiences), and lastly the follow-up questionnaire (mop-up exercise). This might have created the impression of monotony of successive questionnaires.

Future research should look into the applicability of the research project to other areas in South Africa and other sub-Saharan African countries besides South Africa who are at their initial stages of ICT implementation.

The research project could involve investigating the relationship between:

i. The extent of the TPACK of Physical Science educators in relation to Instructional strategies and Technologies.

ii. The extent of the TPACK of Physical Science educators in relation to Fit (Content, Pedagogy, Technology combined).

6.9 Limitations of the instruments and TPACK rubric

Despite, the high validity and reliability indices of the instruments, the adapted TPACK rubric had its own limitations. These were:

i. The instruments were fairly long and made big demands on the participants.

ii. Language used: Some of the language used may not have been familiar to everyday use by participants e.g. words like “methodological approaches” and “merge to make a coherent lesson”. Participants could be using these terms interchangeably to mean the same thing. Thus participants were mixing concepts in their responses.

The results of this research project cannot be generalized due to the sample size which was not large enough and they are unique to the participants involved in this project only as well as unique to the context where the participants are working. Sampling of teachers was a problem as teachers from different teaching and learning context are targeted, therefore, financial resources and time was a limiting factor. More teachers could have been reached. Due to practical considerations the study was limited to only six practicing physical teachers whose schools are seriously involved in ICT integration in Gauteng High schools. Thus a large scale application might provide confirmation of the generalizability of the validity of the results.

Wisdom from a compatriot, a mentor, a respected African businessman, an owner of the giant telecommunication conglomerate laying the optic fiber from Cape Town to Europe said to me lately: *"performance is measured in numbers…you must always try to find ways to measure your performance with numbers. The more you do this, the more respected you would be. Whatever it is you are doing….it must be measured constantly and using numbers. Now you don't have to invent your own numbers, because in every business (education) there are universally agreed numbers"* Strive Masiyiwa (Econet Global- Liquid Telecom, 2015).

I hope the numbers of measures I introduced in TPACK become universally agreed numbers to statistically measure educator effective use of ICTs for pedagogical purposes.

References

Adler, J. and Lerman, S. (2003) Getting the description right and making it count: Ethical practice in mathematics education research. In Bishop, A. & Kilpatrick, J. (Eds.) *Second International Handbook of Mathematics Education. Commissioned chapter.* Kluwer Educational Publishers. Dordrecht, Netherlands.

Albion, P., Jamieson-Proctor, R., & Finger, G. (2010). Auditing the TPACK competence and Confidence of Australian Teachers: The Teaching With ICT Audit Survey (TWictAS). Paper presented at the *Society for Information Technology and Teacher Education Conference (SITE),* San Diego, California, March 29-April 2, 2010.

Angeli, C., & Valanides, N. (2005). Preservice elementary teachers competence and confidence of Australian Teachers: The Teaching with ICT Audit Survey (TWictAS). *Journal of Computer Assisted Learning*, *21* (4), 292–302.

Available online: http://pareonline.net/getvn.asp?v=17&n=3

Baker, F.B. (2001). *The basics of item response theory* (2nd Ed.), USA; ERIC Clearinghouse on Assessment and Evaluation.

Bamberger, M. (2012). *Introduction to mixed methods in impact evaluation.* Retrieved http://www.interaction.org/impact-evaluation-notes.

Batchelor, J. (2014). *Focus on teacher development using ICT in teaching and learning: Issues and challenges.* Proceedings of the 5th Teachers Upfront Seminar (2014), 30th September 2014. University of Johannesburg, Bunting Campus. Johannesburg, South Africa.

Bayraktar, S. (2002). A meta-analysis of the effectiveness of computer-assisted instruction in science education. *Journal of Research on Technology in Education, 34*(2), 173-188.

Bingimlas, K.A. (2009). Barriers to successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science and Technology Education*, 5 (3): 235-245.

Birman, B., Desimone, L., Porter, A.C., & Garet, M. (2000). Designing professional development that works. *Educational Leadership*, 57 (8), 28-33.

Blanchard, M. R., Harris, J., & Hofer, M. (2011). *Science learning activity types*. Retrieved from College of William and Mary, School of Education, Learning Activity Types: http://activitytypes.wm.edu/Science.html

Bliss, J. (1994). Causality and common sense reasoning. In H. Miller, J. Bliss, R. Boohan, J. Ogborn, & Tompsett (Eds.), *learning with artificial worlds: Computer based modelling in the curriculum*. London: Falmer.

Bond, T & Fox, C. (2007). Applying the Rasch Model. Fundamental measurements in the human science (2nd Ed). New Jersey; Lawrence Erlbraun Associates, Inc.

Bond, T. G., & Fox, C. F. (2001). Applying the Rasch Model: Fundamental measurement in the human sciences. Mahwah: Lawrence Erlbaum Associates.

Callingham, R. & Bond, T. (2006). Research in Mathematics Education and Rash Measurement, *Mathematics Education Research Journal*, 18 (2) 1-60.

Cohen, L., Manion, L. & Morrison, K. (2007). Research methods in education (sixth edition). London and New York: Taylor and Francis Group: Routledge.

Cohen, L., Manion, L. & Morrison, K. (2011). Research methods in education. London: Routledge

Common Core State Standards Initiative. (2010, June). Reaching higher: The common core state standards validation committee. A report from the national governor's association centre for best practices and the council of chief state school officers. Retrieved December 30, 1899, from http:// www.corestandards.org/assets/CommonCoreReport_6.10.pdf

Creswell, J. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th Ed.).Upper Saddle River, NJ: Pearson Education.

Crompton, H. (2015). Preparing teachers to use technology effectively using the technological, pedagogical, content knowledge (TPACK) framework. *GLOKALde, 1*(2), 82-92. Retrieved from http://dergipark.ulakbim.gov.tr/glokalde/article/view/5000135241

Cronbach, L. J. (1988). *Construct validation after thirty years*. In R. L. Linn (Ed.), Intelligence: Measurement theory and public policy (Proceedings of a symposium in honour of Lloyd G. Humphreys. Manuscript copy). Urbana: University of Illinois Press.

Cronk, B. C., & West, J. L. (2002). Behaviour Research Methods, Instruments, & Computers. *Journal of Psycholinguistic Research* 34 (2), 177-180.

De Bruin, D. (2011). An introduction to Rasch Measurement [PowerPoints slides]. Presented by Deon & Karina De Bruin & Associates. University of Johannesburg.

Department of Education (DBE) (2012). *Report on the national senior certificate examination 2012. National diagnostic report on learner performance (5 years NSC. Department of Basic Education.* Pretoria. South Africa. http://www.education.gov.za

Department of Education (DBE) (2011). *Report on the national senior certificate examination 2011. National diagnostic report on learner performance (5 years NSC).* Department of Basic Education. Pretoria. South Africa. http://www.education.gov.za.

Department of Education [DOE, South Africa] (2004*). Transforming learning and teaching through information and communication technologies*. (Draft White paper on e-Education, Government Gazette, 246 August 2004): Gazetted Version. Retrieved May 15, 2015 fromhttp://www.polity.org.za/attachment.php?aa_id=1528.

Department of Education [DOE, South Africa] (2007). *Guidelines for Teacher Training and Professional Development in ICT.* Retrieved May 15, 2015 from www.thutong.doe.gov.za/ResourceDownload.aspx?id=35998

Dlamini, R. (2014*). Using ICT in Teaching and Learning: Issues & Challenges.* Proceedings of the 5th Teachers Upfront Seminar (2014), 30th September 2014. University of Johannesburg, Bunting Campus. Johannesburg, South Africa. Doi: 10.4018/978-1-4666-8403-4.

Dooley, D. (2001). Social Research Methods (fourth edition). Eaglewood Cliffs, NJ: Prentice Hall.

Driver, R. (1989). Students' conceptions and the learning of science. *International Journal of Science Education*, 11, 481-490. Doi: 10.1080/0950069890110501

Echevarria, J. & Graves, A. (2007). *Sheltered content instruction: Teaching English language learners with diverse abilities* (3rd Ed.). Boston: Allyn & Bacon.

Echevarria, J. & Short, D. (2009). Programs and practices for effective sheltered content instruction. In D. Dolson & L. Burnham-Massey (Eds.), *Improving education for English learners: Research-based approaches* (pp. 250-321). Sacramento, CA: California Department of Education Press.

Echevarria, J., Short, D., & Vogt, M. E. (2008). *Implementing the SIOP® model through effective professional development and coaching*. Boston: Pearson/Allyn & Bacon.

Equal Education (2016). South Africa: Upcoming 2015 matric results require careful scrutiny: Press release. Retrieved from allafrica.com/stories/201601050255.html

Ertmer, P.A. (2001). Responsive instructional design: Scaffolding the adoption and change process. *Educational Technology*, 41 (6) 33-38.

Ezzy, D. (2002). *Qualitative Analysis*: Practice and innovation. London: Routledge.

Fielding, N. (2010). Mixed methods research in the real world. *International Journal of Social Research Methodology, 13 (2), 127-138.*

Finkelstein, N., Perkins, K. K., Adams, W., Kohl, P. and Podolefsky, N. (2005). Can computer simulations replace real equipment in undergraduate laboratories? *Physics Education Research*, v1 n1 p010103-1--010103-8. American Physical Society. http://prst-per.aps.or.

Fredriksson, U., Jedeskog, G and Plomp, T. (2007). Innovative use of ICT in Schools based on the findings in ELFE project. *Educ INF Technol*, (1), 1-19. DOI 10.1007/s10639-007-9054-4.Springer Science + Business Media, LLC 2007.

Gadermann, A, M., Guhn, M. & Zumbo, B, D. (2012). Estimating ordinal reliability for the Likertype and ordinal item response data: A conceptual, empirical, and practical guide. *Practical Assessment, Research & Evaluation, 17 (3), 1-19.*

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a National Sample of Teachers. *American Educational Research Journal, 38 (4), 915-945.*

Gauteng Department of Education (2014). *Reorganization of education in Gauteng system delivery: Proposed twinning program, meeting with Gauteng members of school governing bodies*, Benoni Convention Centre, (15 August 2014), Johannesburg, South Africa.

Geddis, A. N., & Wood, E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education, 13* (6), 611-626.

Glazer, E., Hannafin, M.J., and Song, L. (2005). Promoting technology integration through collaborative apprenticeship. *Educational Technology Research and Development*, 53 (4), 57-67.

Green, K, E. & Fenton, C, G. (2002). Survey development & validation with Rasch Model. *A paper presented at the International Conference on Questionnaire Development, Evaluation, and Testing*, Charleston, South Carolina. USA.

Greenhow, C., & Robelia, B. (2009). Web 2.0 and classroom research: What path should we take now? *Educational Researchers*, 38 (4), 246-259.

Harris, J. B., Hofer, M. J., Blanchard, M. R., Grandgenett, N. F., Schmidt, D. A., Van Olphen, M., & Young, C. A. (2010). "Grounded" technology integration: Instructional planning using curriculum-based activity type taxonomies. *Journal of Technology and Teacher Education, 18* (4), 573-605.

Harris, J., & Hofer, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum – based technology integration reframed. *Journal of Research on Technology in Education, 41 (4), 393-416.*

Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-based technology integration assessment instrument: In D. Maddux., D. Gibson & B. Dodge (Ends), *Research highlights in technology and teacher education*. Chesapeake. VA: Society for Information Technology and Teacher Education (SITE).

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development. In L. Darling-Hammond and G. Sykes (Eds.), *Teaching as the learning profession*: *Handbook of policy and practice* (pp. 127-150). San Francisco: Jossey Bass Publishers.

Henning, E. (2004). *Finding your way in qualitative research*. Pretoria: Van Schaik.

Hernard, D., H. (2000). Item Response Theory. In L. Grimm & P. Yarnold (Eds).Reading & *Understanding more Multivariate Statistics*, (1), 67-97. USA: .American Psychological Associates.

Hidden Curriculum. (2014). Definition of curriculum. Retrieved edglossay.org/hidden-curriculum.

Hinson, J., La Prairie, K., & Heroman, D. (2006). A failed effort to overcome tech barriers in a K-12 Setting: What went wrong and why? *International Journal of Technology in Teaching and Learning, 2 (2), 148- 158.* Retrieved May 15, 2011 from http://www.sicet.org/journals/ijttl/issue0602/Hinson%20LaPraire%20Haroman%20Vol2%20Issue2.pdf

Hinson, J., Laprairie, K.N., & Cundiff, J.M. (2005). One size does not fit all. *The Journal June 2005*.Retrieved May 15, 2011 from http://thejournal.com/articles/2005/06/01/one-size-does-not-fitall.aspx?sc_lang=en

Hintze, J., & Matthews, W. (2004). The generalizability of systematic direct observations across time and setting: A preliminary investigation of the psychometric of behavioural observation. *School Psychology Review*, 33 (2), 258-270.

Hoban, G.F. (2002). *Teacher Learning for Educational Change: A Systems Thinking Approach*. Philadelphia: Open University Press http://www.researchgate.net/publication/274369878_Sinif_gretmeni_Adaylarinin_Teknolojik_Pedagojik_Alan_Bilgilerinin_Bazi_Degisken- http://www.tqsource.org/issueforums/plantoAction/resources/3_PDPartnershipsandStandards/Dilemmaso fPD.pdf

Jamieson-Proctor, R., Watson, G., Finger, G., & Grimbeek, P.M. (2005). *An External evaluation of education Queensland's ICT curriculum integration performance measurement instrument* Brisbane, Qld: Griffith University.

Jamieson-Proctor, R., Finger, G., & Albion, P. (2010a). Auditing the TK and TPACK confidence of -service teachers: Are they ready for the profession? *Australian Educational Computing, 25*(1), 8–17.

Jedeskog, G. (2005). *Changing school. Implementation of ICT in Swedish School. Campaigns and experiences 1984–2004*. Uppsala: Uppsala University, Department of Education.

Jimoyiannis, A., and Komis, V. (2001). Computer simulations in physics teaching: a case study on students' understanding of trajectory motion. *Computers & education, 36*, 183-204.

John, V. (2015, April 24). *Good Teachers in short supply.* Mail & Guardian.

Johnson, R. B., & Onwuegbuzie, A.J. (2004). Mixed methods research: a Research paradigm whose time has come. *Educational Researcher, 33 (7), 14-26.*

Jonassen, D., Howland, J., Marra, R., & Crismond, D. (2008). Meaningful learning with technology (3rd Ed.). Upper Saddle River, NJ: Pearson.

Kafyulilo, A., Fisser, P., Pieters, J., & Voogt, J. (2015). ICT use in science and mathematics teacher education in Tanzania: Developing technological pedagogical content knowledge. *Australasian Journal of Educational Technology,* 31 (4). 381-399. Retrieved from http://ajet.org.au/index.php/AJET/article/viewFile/1240/1288

Kelle, U. (2001). 'Sociological explanations between micro and macro and the integration of qualitative and quantitative methods'. *Forum: Qualitative Social Research,* 2 (1).

Kim, D. & Barton, K. (2010). *Sample size impact of screening methods in the Rasch Model.* A paper presented at the American Educational Research Association, Denver. Colorado. USA.

Kind, V. (2009). Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education*, 45:2, 169-204.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. AACTE Committee on Innovation and Technology. *The handbook of technological pedagogical content knowledge (TPCK) for educators (pp. 3–29).* Mahwah, NJ: Lawrence Erlbaum Associates.

Koehler, M., & Mishra, P. (2008). Introducing TPCK. In AACTE committee on innovation and technology (Ed.), *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-31). New York: Routledge.

Koehler, M.J., & Mishra, P. (2009). What is technological pedagogical content? Knowledge? *Contemporary Issues in Technology and Teacher Education, 9, 60–70.*

Kozma, R. J. (Ed.) (2003*). In Technology, innovation, and educational change: A global perspective. A report on the Second Information Technology in Education Study (SITES) Module 2.* Eugene, OR: International Society for Technology in Education (ISTE).

Lawless, K.A., & Pellegrino, J.W. (2007). Professional development in integrating technology into teaching and learning: Knows, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, 77 (4), 575-614. Retrieved May 15, 2011 from http://rer.sagepub.com/content/77/4/575.full.pdf

Lehiste, P. (2015). The impact of a professional development program on in-service teachers' TPACK: A study from Estonia. Problems of Education in the 21st Century, 66, 18-28.Retrieved from http://oaji.net/articles/2015/457-1441441936.pdf

Liao, Y. K. C. (1999). Effects of hypermedia on students' achievement: A meta-analysis. *Journal of Educational Multimedia and Hypermedia, 8 (3), 255–277.*

Likert, R. (1932). *A Technique for the measurement of attitudes.* New York: Columbia University Press.

Limerick, B., Burgess Limerick, T. and Grace, M. (1996). The politics of interviewing: power relations and accepting the gift. *International Journal of Qualitative Studies in Education, 9 (4), 449-60.*

Linacre, J, M. (2011). WINSTEPS (VERSION 3.72.3) [Computer software].Chicago:winsteps.com. Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic Inquiry (1st Ed., Pp. 332-409). London: SAGE Publications.

Linacre, J. M. (2009). *WINSTEPS*. Retrieved from www.winsteps.com/winsteps.htm.

Linacre, J.M. (2012). Winsteps® (Version 3.74.0) [Computer Software]. Beaverton, Oregon: Winsteps.com. Retrieved January 1, 2012. Available from http://www.winsteps.com/.

Liu, X. (2010). *Using and Developing Measurement Instrument in Science Education: A Rasch Modelling Approach.* USA: Information Age Publishing.

Livingstone, S. (2012). *Critical reflections on the benefits of ICT in education*. *Oxford Review of Education*, 38:1, 9-24, DOI: 10.1080/03054985.2011.577938

Lunz, M.E. (2010). Using the very useful Wright map. Retrieved July 4, 2011 from Measurement Research Associates Ten Insights: http:www.rasch.org/mra/mram01-10.htm.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N.G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Dordrecht, the Netherlands: Kluwer Academic Publishers. Dordrecht, Netherlands.

Mavhunga, E. & Rollnick, M. (2013) Improving PCK of chemical equilibrium in pre-service teachers, *African Journal of Research in Mathematics, Science and Technology Education,* 17:1-2, 113-125.

Mavhunga, E., & Rollnick, M. (2011). *The development and validation of a tool for measuring topic specific PCK in chemical equilibrium*. Paper presented at the ESERA Conference, Lyon, France.

Mavhunga, M. (2012). Explicit inclusion of topic specific knowledge for teaching and the development of PCK in Pre-Service science teachers. *A Thesis to the Wits School of Education, Faculty of Humanities, University of the Witwatersrand*. Johannesburg.

Maxwell, J. A. (2005). *Qualitative research design: An integrated approach.* (2nd Ed.). Thousand Oaks: Sage Publications. Chapter 3: Conceptual framework: What do you think is going on? Read pp. 33-55.

Maxwell, J. A., & Loomis, D. M. (2003). Mixed methods design: An alternative approach. In A. Tashakkori, & C. Teddlie (Eds.), *Handbook of mixed methods in social & behavioural research (pp. 241-271).* Thousand Oaks: Sage Publications Inc.

Mayer, D. P. (1999). Measuring instructional practice: Can policymakers trust survey data? Educational Evaluation and Policy Analysis, 21 (1), 29-45.

McCormick, R. and James, M. (1998). Curriculum Evaluation in Schools (second edition). London: Croom Helm.

McHugh, M, L. (2012). Interrater reliability: the kappa statistic. BiochemMed (Zagreb). 2012; 22 (3): 276-83.PIMD23092060

Mdlongwa, T. (2012). *Information and Communication Technology (ICT) as a means of enhancing education in schools in South Africa: Challenges, benefits and recommendations.* Africa Institute of Institute of South Africa. Policy Briefing No. 80, August 2012. From <http://www.ai.org.za/wp-content/uploads/downloa ds/20 12 /10 /No.-80. -ICTa s-amea ns-of-enha ncing-Edu ca tion-in-School s-in-South-Africa. Pdf> (Retrieved on 15 March 2015).

MEC Education (2015). *Teaching and learning is getting more and more tech-Savvy.* anc.org.za/docs/anctoday/2015/at 26htm#art2: Retrieved July 27, 2015.

Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*.San Francisco: Jossey-Bass.Messick (1989, p.6) Messick, S. (1989). Meaning and values in test validation: The science and ethics of assessment. Educational Researcher, 18 (2), 5–11.

Miles, M.B, and Huberman, A.M. (1994). *Qualitative Data Analysis,* 2nd Ed., p. 10-12. Newbury Park, CA: Sage.

Millar, R. & Driver, R. (1987). Beyond processes. *Studies in Science Education, 14,* 33-62.

Mishra & Koehler (2006*).* Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108 (6), 1017-10 54.*

Mji, A. & Makgato, M. (2006). Factors associated with high school learners' poor Performance: a spotlight on mathematics and physical science. *South African Journal of Education 26 (2) 253-266.*

Moran-Ellis, J., Alexander, V. D., Cronin, A., Dickinson, M., Fielding, J., Sleney, J., & Thomas, H. (2006). Triangulation and integration: processes, claims and implications. *Qualitative Research*, 6 (1), 45-59.

Mudindo, M., & Doidge, M. (2016). *Educators' integration of ICT's in teaching Mechanics in grade 10 Physical Sciences in three approved South African high schools.* Paper presented at the 24th annual meeting of the Southern African Association for Research in Mathematics, Science and Technology Education. Tshwane University of Technology, Pretoria.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Technology for Teacher Education*, *9*(3), 319–342. http://doi.org/10.1080/14759390000200096

National Planning Commission (2012). *Executive Summary – NDP 2030 – Our future – make it work.* Pretoria, Department: The Presidency.

National Research Council. (2000). *Inquiry and the national science education standards.* Washington, DC: National Academy Press.

Ndlovu, M., Mavhunga, E., & Rollnick, M. (2013). *The Design of an instrument to measure Physical sciences teachers' topic specific pedagogical content knowledge in electrochemistry.* Paper presented at the 21st annual meeting of the Southern African Association for Research in Mathematics, Science and Technology Education. Cape Town.

Ndlovu. N.S. & Lawrence, D. (2012*). The quality of ICT use in South African Classrooms.* Paper presented at the C3 towards Carnegie III conference: Strategies to overcome poverty & inequality. University of Cape Town. South Africa. Pan African Research Agenda on the Pedagogical Integration of Information and Communications Technologies, South Africa (PanAf). Database, http://www.observatoiretic.org"

Ndongfack, M. N. (2015). TPACK constructs: A sustainable pathway for teachers professional development on technology adoption. *Creative Education*, 6 (16), 1697-1709. doi:10.4236/ce.2015.616171.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with Technology: Developing a technology, pedagogical content knowledge. *Teaching and Teacher Education. 21*(5), 509-523.

Onwuegbuzie, A. J., & Teddlie, C. (2003). A framework for analysing data in mixed methods research. In A. Tashakkori, & C. Teddlie (Eds.), *Handbook of mixed methods in social & behavioural research (pp. 351-383).* Thousand Oaks: Sage publications Inc.

Opie, C. (2004). *Doing Educational Research - A Guide for First Time Researchers*. London: Sage Publications.

Opie, C. (2004). Research Procedures. In Clive Opie (Ed*), Doing Educational Research.* SAGE. London. pp 95-110.

Ornek, F., Robison, W.R, & Haugan, M.P. (2008). What makes Physics difficult? *International Journal of Environment & Science Education, 3 (1), 30-34.*

Owusu, K. A., Conner, L., & Astall, C. (2015). Contextual influences on science teachers' TPACK levels. In M. Niess & H. Gillow-Wiles (Eds.), *Handbook of Research on Teacher Education in the digital age (pp. 307-333).* Hershey, PA: Information Science Reference.

Oyoo, S. O. (2009). *Beyond general proficiency in language of instruction: Towards the appropriate perspective on language for effective learning in African science classrooms*. In M. Shafer and C. MacNamara (Eds.), Proceedings (Refereed) of the 17th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE 2009), 19–22 January 2009, Rhodes University, Grahamstown.

Oyoo, S.O. 2011. *Foreign languages in African science classroom: Perspectives on and approaches to language use during teaching.* In Refereed proceedings of the distance education and teachers' training in Africa, Conference, 3-5 August 2011, pp 121-146. Edited by Dr. A. Aluko & Dr. F. Januario. Universidade Eduardo Mondlane, Maputo, Mozambique.

Ozturk, E. (2013). Prospective classroom teachers' technological pedagogical content knowledge assessment in terms of some variables (TPCK). *Usak University Journal of Social Sciences*, 6 (2), 223-228.Retrieved from

Park, H., Khan, S., and Petrina, S. (2008). ICT in Science Education: A quasi-experimental study of achievement, attitudes toward science, and career aspirations of Korean middle school students. *International Journal of Science Education*, iFirst Article, 1-20.

Pearson, M., & Naylor, S. (2006). Changing contexts: Teacher professional development and ICT pedagogy. *Education and Information Technologies, 11, 283–291.*

Phillipson, S., Subramaniam, T., Tomkinson, E., Walker, R., and Young, A. (2011). Advances in learning environments research. In R.F.Cavanagh & R.F, Waugh (Eds), *Applications of Rasch Measurement in Learning Environments Research*. Boston; Sense Publishers.

Richardson, V. (2003). *The dilemmas of professional development*. Phi Delta Kappan, Retrieved May 25, 2015 from:

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A Systematic Review. *Journal of Research on Technology in Education*, 47 (3), 186–210. doi:10.1080/15391523.2015.1052663-

Rotbain, Y., Marbach-Ad, G., and Stavy, R (2008). Using a computer animation to teach high school molecular biology. *Journal of Science Education Technology*, *17*, 49-58.

Royer, R. (2002). *Supporting technology integration through action research*. The Clearing. House, 75, 233-7.

Saldana, R. J. (2015). *Mobile professional development: Taxonomic levels of learning on teachers' TPACK perceptions and acquisition of technology competencies (Doctoral dissertation)*. Available from ProQuest Dissertations and Theses Global database. (UMI No. 3708564).

Sandelowski, M. (2003). Tables or tableaux? The challenges of writing and reading mixed methods studies. In A. Tashakkori, & C. Teddlie (Eds.), *Handbook of Mixed Methods in Social & Behavioral Research (pp. 321-350).* Thousand Oaks: Sage Publications Inc.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Education Researcher, 15 (2), 1-14.*

Shulman, L. S. (1987). Knowledge and training: Foundations of the new reform. *Harvard educational Review, 57,* 1-22.

Slough, S. & Slough, P. (2015). 21st century pedagogical content knowledge. In S. Carliner, C. Fulford & N. Ostashewski (Eds.), Proceedings of EdMedia: World Conference on Educational Media and Technology 2015 (pp. 1207-1214). Waynesville, NC: Association for the Advancement of Computing in Education (AACE). Abstract retrieved from http://www.editlib.org/p/151382/-

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioural sciences*. Thousand Oaks, CA: Sage.

Thesaurus Dictionary (2016). . From <http: //www. Thesaurus .com> (Retrieved on 05 March 2016).

Tobin, K. (2006). *Doing educational research: Qualitative research in Classrooms: Pushing the boundaries of theories and methodology*. Rotterdam: Sense Publishers.

Twining & McCormick (1999). Learning schools program: Developing teachers' information communication technology competence in the support of learning. In J. Price et al. (Eds.), *Proceeding of Society for Information Technology & Teacher Education*. International Conference 1999 (pp 1703-1708). Chesapeake, VA: AACE.

Twining, P. and F. Henry (2012). Staff observations & debriefing. The work made available under the terms of the Creative Commons Attribution-Share Alike 3.0 licen http://creativecommons.org/licenses/by-sa/3.0/.

Voogt (2012). *ICTs for Curriculum Change. UNESCO Institute for Information Technologies in Education Policy Brief*. From <http: //www. iite. unesco.org> (Retrieved on 05 July 2013).

Webb, M. (2005). Affordances of ICT in science learning: Implications for an integrated pedagogy. *International Journal of Science Education, 27* (6), 705-735.

Williams, D., Coles, L., Wilson, K., Richardson, A., & Tuson, J. (2000). Teachers and ICT: Current use and future needs. *British Journal of Educational Technology*, 31 (4), 307-320.

Wright, B. D. (1996). *Reliability and separation. Rasch Measurement Transactions*, 9, 472. Retrieved 11 March 2015 from www.rasch.org/rmt/rmt94n.htm.

Wright, B.D., & Masters, G.N. (1982). *Rating scale analysis*, Chicago: MESA Press, especially p.100: www.rasch.org/books.htm.

APPENDICES

Appendix A1: Ethics letter of approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064
Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

02 June 2015

Student Number: 676997

Protocol Number: 2015ECE022M

Dear Fumai Mudindo

Application for Ethics Clearance: Master of Science

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools

The committee recently met and I am pleased to inform you that **clearance was granted**. However, there were a few small issues which the committee would appreciate you attending to before embarking on your research.

The following comments were made:

- **Minor issues as per comments on the form**

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMabeta
Wits School of Education

011 717-3416

Cc Supervisor: Dr Megan Doidge and Dr Reuben Dlamini

Appendix A2: Gauteng Department of Education approval letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no: D2016 / 208
enquiries: Diane Buntting 011 843 6503

GDE RESEARCH APPROVAL LETTER

Date:	**14 August 2015**
Validity of Research Approval:	**14 August 2015 to 2 October 2015**
Name of Researcher:	**Mudindo F.M.**
Address of Researcher:	**76 Smitshof Mansions; 1 Hospital Street; Braamfontein; 2001**
Telephone / Fax Number/s:	**011 726 7000; 084 770 0397; 011 482 3183**
Email address:	**mfumai@yahoo.com**
Research Topic:	**Educators' integration of ICT in teaching Mechanics in Grade 10 Physical Science in three South African Schools.**
Number and type of schools:	**THREE Secondary Schools**
District/s/HO	**Ekurhuleni North; Ekurhuleni South and Johannesburg South.**

Re: Approval in Respect of Request to Conduct Research

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

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

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter;

2015 / 08 / 17

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

2. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB);
3. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned;
4. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, SGBs, teachers and learners involved. Participation is voluntary and additional remuneration will not be paid;
5. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage;
6. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year;
7. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
8. It is the researcher's responsibility to obtain written parental and learner consent;
9. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources;
10. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations;
11. On successful completion of the study the researcher must supply the Director: Education Research and Knowledge Management with an electronic copy (and a Hard copy if possible) as well as a Research Summary of the completed Research Report;
12. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned; and
13. Should the researcher have been involved with research at a school and/or a district office level, the Director and school concerned must also be supplied with the Research Summary of the study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2015/08/17

2

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0606
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix A3: Initial Questionnaire

School C: 0001

Initial Questionnaire (Structured Questionnaire)

This research project investigates *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

The aim of this initial-Questionnaire is for the Educator to appraise/inform the researcher on how he/she does the process of preparation to integrate ICT in the teaching of Mechanics.

The spaces provided would be used by the researcher to takes notes in case the audiotaping machine malfunctions.

Pseudonym	

1. What approach do you use during lesson preparation to teach the topic of Mechanics using ICT?

2. Which software do you use and how do you identify this type of software for the purpose of teaching Mechanics if not part of standard tablet package?

3. Where do you source the software or technologies for teaching Mechanics?

4. How do you merge or sort the content that would be taught and the type of technology that would be used them to have a coherent and meaningful lesson?

5. Is there any difference in the time that it took for you to prepare for a traditional lesson compared to now when you have integrated ICT into your teaching?' Elaborate.

6. What other activities are done to achieve meaningful lessons besides the above mentioned?

7. To what extent has the training that you received from the (DoE) or (Name provider--) to use ICT in the classroom been useful (i) for your lesson preparation, and (ii) with teaching your topic during class?'

Appendix A4: Summary of responses to the Main Questionnaire instrument

1.

Pseudonym	What approach do you use during lesson preparation to teach the topic of Mechanics using ICT?
Mr Ariel	Mechanics is visual. A student will excel if he can see what he is working with.
Mr Johns	I prepare lessons in such a way that the learner is able to: Learn by doing. Discover rules/laws experimentally. Interact with information through written activities.
Ms Nomsa	I use learner centred approaches, which is part of the constructivist. Paradigm. I believe learners come to mechanics topic with pre or prior knowledge but most of the times the knowledge is not well-grounded in scientific principles. My preparation takes into account note-taking, visual aids, use of demonstrations, exercises and others.
Mr Zuva	Identify short questions that can be used in Learning Management System. Find YouTube video that explains concept well unless that 5 minutes. Look for or develop PowerPoint slides explaining concept. Look in textbook or alternative source for worksheet on topic. Look for simulation that mimics concept that learners can use.
Mr Sibeko	Online collaboration with learners and parents to help with homework and assignments. Presentations to make lessons more visual and stimulating. Using tablets with google to help learners do online research. Lecture capturing allows teacher to record lessons and copy to a CD and give to learners for help. Smart phones can be used as clickers to do pole questions and answers. Visual art and images online can help with better understanding. Online videos of difficult to explain topic can also help with understanding. I include as many of the above strategies into my lesson planning to incorporate all learning styles of learners.

2.

Pseudonym	Which software do use and how do you identify this type of software for the purpose of teaching Mechanics if not part of standard tablet package?
Mr Ariel	Auto Cad PowerPoint Java Need to experiment and see what works for individuals
Mr Johns	I use the following software: PowerPoint Presentations to quickly give information. Microsoft Word – to create texts and worksheets. YouTube videos to ensure that learners see what other experiments/lists have

	done on the subject topic. Animation software much as PHET. Microsoft Excel: for data manipulation and drawing of graphs /charts. Maths and Science Marketing website.
Ms Nomsa	I use the Sangari South Africa, I-Box recommended by the Department of Education. This software has got pre-planned. Lessons arranged to the Caps document. The i-Box has video content, Phet Animations and films to do with the topic in question. The tablets delivered had not teaching material for educators.
Mr Zuva	SMART Notebook. Phet simulations DesignMate 3D Software Intel skool simulations LearnTL
Mr Sibeko	Word processing software which was included in the tablet package helps learners to type answers to questions and using Bluetooth can send to teachers computer and displayed on classroom screen. I downloaded some software online like google maps to explore the earth, scholarly software to share questions and answers with learners in real time on the net. Mostly the current tablet project is not working well. The GDE should open up software options to download for free to help with most subject matter.

3.

Pseudonym	**Where do you source the software or technologies for teaching Mechanics?**
Mr Ariel	Personal or Computer Technicians
Mr Johns	Ms Package came standard with the computer. YouTube videos are downloaded from the internet. Extra software is downloaded from the internet. Maths & Science Marketing website.
Ms Nomsa	Sangari South Africa I-box contains all the materials. PowerPoint, Phet Animations, downloaded YouTube videos, Graphic Instruments and Evaluation Techniques.
Mr Zuva	SMART Notebooks – cones with SMARTBOARD. Phet simulations available on internet – Google Colorado University Phet simulations. DesignMate 3D software from Edu board. Intel skool simulations
Mr Sibeko	At the moment I pay for software myself or I search the net for appropriate tools that’s free.

4.

Pseudonym	How do you merge or set the content that will be taught and the type of technology will be used them to have a coherent and meaningful lesson?
Mr Ariel	I research the topics and see which workshop best fits the topic than merge them.
Mr Johns	I first identify the type of experiments or demonstration, I need to include in the lesson. These demonstrations or experiments are listed under Caps as formal or informal experiments. Internet search for the specific experiment gives the videos that are added on the PowerPoint Presentation. The thing of the demonstration is meant to integrate theory with real life experiences. Learners are also given an opportunity to do the experiment.
Ms Nomsa	I'm a Physical Science trained educator, I have the knowledge of the content and therefore I have the ability to arrange the lesson accordingly. I select exercise that fit my timetable. I select Phet Animations I want to use for demonstrations and the ones I want learners to review until the concepts are understood. Then arrange practicals when suitable.
Mr Zuva	Files used for lessons are folders per lesson. Lessons follow a specific order. SMM test (electronic) Video or interactive digital resource. PowerPoint presentation. Worksheet.
Mr Sibeko	Most of all my lessons use technology to help learners not only understand the subject matter, but also help them get a working understanding on how to use the technology. I do try and use the tools and software according to lessons learned. E.g. the calculator on the tablets can be used to calculate difficult equations while the word processor can be used to type the answers. Answers can be sending via Bluetooth and displayed on screen.

5.

Pseudonym	Is there any difference in the time that it took for you to prepare for a traditional lesson compared to now when you have integrated ICT into your teaching? Elaborate.
Mr Ariel	Yes, it takes more time now as PowerPoint takes time to iron out the problems and the time but once it is done you can use it and edit whenever.
Mr Johns	Yes, the ICT lesson needs a list of planning and a good eye for detail, hence more time is needed. Internet is full of some useful info so the teacher needs to be careful. Arrangement of the lesson outcomes takes time. In the traditional lesson, I would do a standard lesson plan and materials mostly include learner textbooks. Activities are already included.
Ms Nomsa	The traditional lessons took time to prepare because you had to start from

	scratch. These ICT lessons they are there from Sangari and approved by The Department of Education and therefore you require less time. The best way is to go through them and know if the content is good and no misconceptions or will lead to misconceptions or total error.
Mr Zuva	Initially setting-up e-lessons takes time, but resources are shared and easier. This means that I might spend time preparing a lesson for Grade 9 NS but the lesson for Grade 10 Physical Science has been set for me. In the long-term it saves time. Lessons and charges are easier stirred for the future.
Mr Sibeko	No, in fact it goes much faster as I type faster that I write and finding tools and materials is a click away. Traditionally you have to page through lots of books to find any information or ides.

6.

Pseudonym	What other activities are done to achieve meaningful lessons besides the above mentioned?
Mr Ariel	Practical time in workshops help stimulate the students.
Mr Johns	Filming of experiments before learners arrive. This creates a back-up in the case that I fall ill. Send learners' activities to read or do before they come for the lesson. Email & WhatsApp platforms are used.
Ms Nomsa	Learners must know how to use the desktop computers and the use of the mouse. Learners are then all taught how to access the lesson for that particular week, the animations, the PowerPoint and the videos. Learners finally are given activities that require them to type, make their own videos and shoot their own CAPS related experiments.
Mr Zuva	Interactive content used. 3D DesignMate visualisation used. Constant testing within the purposes. Making video clips of experiment done to give to learners so that they can view experiment more than once.
Mr Sibeko	Learners are still subjected to outside stimulation. We regularly go outside to discover nature in person. We also do experiments the old fashion way. Only now I have a camera on my desk to show the experiment to the class on the big screen.

7.

Pseudonym	To what extent has the training that you received from the (DoE) or (Name provider…….) to use ICT in the classroom been useful (i) for you lesson preparation, and (ii) with teaching your topic during class?

Mr Ariel	I never received training.
Mr Johns	Self-coached and no formal training was given.
Ms Nomsa	Sangari South Africa taught us how to use their programmes. Involves setting the Power Point Where to source animation & video content. How to set clickers in order to carry out evaluation (although difficult at times). How to do evaluators and how to access outputs.
Mr Zuva	Training from Intel – Better organisation of files and classroom dynamics. Better presentation quality in my PowerPoints. Training from SMART – Confidence in using interactive board. Training from I School Africa to make video clips.
Mr Sibeko	I did most of my training at UNISA. I had subjects in web designing and computer integration to programming. This helped a lot. I'm capable of doing just about everything with my technology. That said the GDE can work harder to improve their workshops.

Appendix A5: OBSERVATION SCHEDULE instrument

School C: 0001

OBSERVATION SCHEDULE: **Reproduced by permission of the publisher, © 2012 by tpack.org**

Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.

OBSERVATION A

EDUCATOR CODE: WITSED001 MALE/ FEMALE…………………………..

AGE:……………………………… Highest Qualification………………………

Observation	*Technology Knowledge-Digital Technologies*	*Comments*
1	What digital technologies are being used?	
2	Is he/she comfortable using digital technologies?	
3	Does he/she keep the class captivated by these digital technologies?	
4	Does he/she know how to solve own technical problems when they occur?	
5	Does he/she have the technological skills needed to use digital technologies to offer vivid explanations in learning situation?	
6	Does he/she have the technological skills needed to use digital technologies to achieve teaching and learning goals of the Topic?	
Other		

Appendix A6: SUMMARY OF PARTICIPANTS RESPONSES

	OBSERVATIONS					
Participant	1	2	3	4	5	6
Mr Ariel	Laptop; projector	Yes those that he has seemed to have mastered	Monolithic to PowerPoint	Yes	No	Low
Mr Johns	Laptop; projector, I-box	Yes he is comfortable	Kept them captivated	Yes	Yes	High
Ms Nomsa	Laptop; I-box	Yes to the use of I-box	Moderately captivated because monolithic to I-box	Yes	Yes	Moderate
Mr Zuva	Interactive Smart Television; Edu trade Desk; Laptop	Yes, he is almost an expert to everything he is using.	Highly captivated	Yes	Yes	Very High
Mr Khumo	Interactive Smart Television	Yes he has an expertise on the use of Interactive Smart Television.	Moderately captivated	Yes	Yes	High
Mr Sibeko	Laptop; projector	Yes he has a lot of gadgets but mostly not used during mechanics teaching	Moderately captivated to sometime distracting	Yes	Yes	Moderate

Appendix A7: OBSERVATION B

Appendix A7a: Science Procedural Building strategies & activities

Blanchard, M. R., Harris, J., & Hofer, M. (2011).

Activity Type	**Brief Description**	**Possible Technologies**
Learn and Practice Safety Procedures	Students learn how to safely and appropriately handle equipment	Video clips, document camera
Measure	Students learn how to make measurements appropriately with specific tools (e.g., graduated cylinder, motion sensor)	Probeware, content-specific interactive tools (e.g., ExploreScience)
Practice	Students practice using equipment, software, measuring, testing what they have designed, etc.	Web-based software or software tutorials, probeware, document camera
Prepare/Clean Up	Students organize equipment or information for the laboratory	Document camera, projector
Carry Out Procedures	Students run trials or otherwise carry out steps to investigations (e.g. use an electronic balance)	Simulation, curriculum software
Observe	Students make observations from physical or digital experiences	Document camera, WebCam, digital/video cameras, digital microscopes
Record Data	Students record observational and previously recorded data in tables, graphs, images, lab notes	Spreadsheet, word processing software, database, handheld computer, tablet computer
Generate Data	Students generate data (e.g. heart rate, cooling water temperatures) by manipulating equipment or animations	Curriculum software, graphing calculators, probeware, digital balance
Collect Data	Students collect data with physical objects or simulations	Graphing calculators, video, audio, digital cameras, digital microscope, Web-based data sets
Collect Samples	Students obtain samples/items to study (e.g., soil, bird songs, video footage)	Digital cameras, videos, audio recorder
Compute	Students calculate results from data	Scientific calculator, spreadsheet

Appendix A7b: *Science* Conceptual Building strategies & activities

Blanchard, M. R., Harris, J., & Hofer, M. (2011).

Activity Type	Brief Description	Possible Technologies
Read Text	Students extract information from textbooks, laboratories, etc.; both print-based and digital formats	Web sites, electronic books, online databases, magazines
Attend to Presentation/ Demonstration	Students gain information from teachers, guest speakers, and peers; in person or via video, oral or multimedia	Presentation software, document camera, video
Take Notes	Students record information from lecture, presentation, group work	Word processing software, wiki, concept mapping software
View Images/Objects	Students examine both still and moving (e.g., video, animations) images/objects; print-based or digital format	Document camera, digital microscope, digital camera, video,(e.g., documentaries or debates), Web sites
Discuss	Students engage in dialogue with one or more peers or the entire class; synchronous/asynchronous	Online discussion forum, email, chat, blog, videoconferencing, interactive white board
Participate in a Simulation	Students interact with live or digital simulations that enable students to explore science content	Curriculum software, Web-based simulations, student response system (“clickers”)
Explore a Topic/Conduct back ground research	Students gather information/conduct background research using print-based and digital sources	Web search engines, digital archives
Study	Students study terminology, classifications, test review, etc.	Web sites, quiz software, online text supplements, wiki
Observe Phenomena	Students observe phenomena that raise scientific questions from physical objects, organisms, or digital media	Video clips, digital microscope, document camera, presentation software
Distinguish Observations from Inferences	Students distinguish directly observed sensory input from inferences requiring background knowledge	Interactive whiteboard, document camera, video clips, audio recording
Develop Predictions, Hypotheses, Questions, Variables	Students develop/think about predictions and select pertinent hypotheses, testable questions, and variables	Word processing software, interactive whiteboard, concept mapping software, wiki
Select Procedures	Students select procedures and accompanying instruments to test hypotheses and/or answer questions	Probeware, digital stirrer, video/audio recorder, digital camera, digital timer, graphing calculator

Sequence Procedures	Students sequence the order of procedures to collect relevant data	Simulation, curriculum software, word processing software
Organize/Classify Data	Students create a structure to organize data collected	Database, spreadsheet, concept mapping software
Analyse Data	Students recognize patterns, describe relationships, understand cause-and-effect, prioritize evidence, determine possible sources of error/discrepancies, etc.	Spreadsheet, TinkerPlots, graphing calculator, statistical software
Compare Findings with Predictions/ Hypotheses	Students evaluate their findings in relation to their hypotheses	Spreadsheet, TinkerPlots, InspireData
Make Connections between Findings & Science Concepts/Knowledge	Students link their findings to concepts in the text/research publications	Web search engines

Appendix A7c: Science Knowledge Building strategies & activities

Blanchard, M. R., Harris, J., & Hofer, M. (2011).

Activity Type	Brief Description	Possible Technologies
Respond to questions	Students respond to teacher-supplied, peer-written, published, or digitally posed questions (e.g., that require short answers, explanations, or elaborations)	Curriculum software, word processing software, quiz software, Web sites, online discussion forum
Write a Report	Students write a laboratory or research report	Word processing software, presentation software, video creation software, wiki, podcast
Create an Image	Students create an image to demonstrate their knowledge of a science concept and/or process	Drawing software, digital camera, comic creation software,
Present or Demonstrate	Students present or demonstrate laboratory or research findings, or other course learning (e.g. a system of the human body)	Presentation software, video creation software, document camera, podcast, Glogster
Take a Quiz or Test	Students respond to questions on a test or quiz	Curriculum software, word processor, quiz software, Web sites, student response system
Debate	Students discuss opposing viewpoints embedded in science content knowledge, linked to ethics, nature of science, personal preferences, politics, etc.	Videoconferencing, discussion board, personal/student response system
Develop or Build a Model	Students physically or digitally create models to demonstrate content knowledge, conduct experiments, etc. (e.g. cell model, rubber band car)	Modeling software, drawing tool, concept mapping software
Draw/Create Images	Students physically or digitally draw or create images (from labs, observations, etc.)	Drawing software, digital camera, image editing software
Develop a Concept Map	Students participate in or develop graphic organizers, semantic maps, etc.	Concept mapping software, interactive whiteboard, drawing software
Play a Game	Students participate in games; group or individual; digital or physical; original or pre-made.	Curriculum software, personal/student response system, web-based games
Develop a Game	Students develop a physical or digital interactive game	Word processing software, web authorizing software, videogame development software (e.g. MIT Media Lab)
Create/Perform	Students create and/or perform a script, rap, song, poem, collection, poster, invention, exhibit, etc.	Video, audio recorder, digital camera, document camera, word processing software, Glogster, video creation software, wiki, Web authoring software, presentation software

Appendix A8: SUMMARY OF RESULTS OF THE OBSERVATION CATEGORIES

SUMMARY OF THE OBSERVATION CATEGORIES			
CATEGORY	KNOWLEDGE BUILDING ACITIVITY TYPE	CONCEPTUAL BUILDING ACTIVITY TYPE	PROCEDURAL BUILDING ACTIVITY TYPE
	12	17	11
Participant			
Mr Ariel	4	4	2
	Respond to questions; Draw Images; Write a Report; Respond to questions;	Observe Phenomena; Take Notes; Attend to Presentation; Read Text;	Learn and Practice Safety Procedures; Compute;
Mr Johns	10	10	6
	Respond to questions; Develop a Concept Map Draw/Create Images Develop or Build a Model Debate Take a Test Demonstrate Create an Image Write a Report Respond to questions	Compare Findings with Predictions/ Hypotheses; Analyse Data; Select Procedures; Develop Predictions, Hypotheses, Questions, Variables; Observe Phenomena; Participate in a Simulation; Discuss; View Images/Objects; Take Notes; Attend to Presentation/ Demonstration; Read Text.	Learn and Practice Safety Procedures; Measure; Practice; Carry Out Procedures; Observe; Record Data; Compute
Mr Sibeko	6	4	3
	Respond to questions; Develop a Concept Map Draw Images Take a Test Write a Report Respond to questions	Develop Predictions, Hypotheses, Questions, Variables; Take Notes; Attend to demonstration; Read Text.	Learn and Practice Safety Procedures; Measure; Carry Out Procedures; Observe;
Ms Nomsa	8	6	3
	Respond to questions; Develop a Concept Map Draw/Create Images Debate Take a Test Present Demonstrate Write a Report Respond to questions	Compare Findings with Predictions/ Hypotheses; Sequence Procedures; Select Procedures; Develop Predictions, Hypotheses, Questions, Variables; Take Notes; Attend to Presentation/ Demonstration;	Learn and Practice Safety Procedures; Measure; Carry Out Procedures; Observe;

		Read Text.	
Mr Khumo	8	7	4
	Respond to questions; Develop a Concept Map Draw Images Debate Take a Quiz or Test Present Write a Report Respond to questions	Develop Predictions, Hypotheses, Questions, Variables; Observe Phenomena; Participate in a Simulation; View Images/Objects; Take Notes; Attend to Presentation/ Demonstration; Read Text.	Learn and Practice Safety Procedures; Measure; Carry Out Procedures; Observe;
Mr Zuva	10	13	8
	Respond to questions; Develop a Concept Map Draw/Create Images Develop or Build a Model Debate Take a Test Present Create an Image Write a Report Respond to questions	Compare Findings with Predictions/ Hypotheses; Analyse Data; Organize/Classify Data; Sequence Procedures; Develop Predictions, Hypotheses, Questions, Variables; Observe Phenomena; Participate in a Simulation; Discuss; View Images/Objects; Take Notes; Attend to Presentation/ Demonstration; Read Text.	Learn and Practice Safety Procedures; Measure; Carry Out Procedures; Observe; Record Data; Generate Data; Collect Data; Compute.

Appendix A9: Main Questionnaire instrument

School C: 0001

Questionnaire

This research project investigates *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

The aim of this questionnaire is to collect basic background information and your perceptions on the integration of ICT in your teaching of a Physical Science topic.

1. Demographic & Background Information

1.1 Personal Information

Pseudonym	
Qualification	
Experience in ICT integration (years/ months)	

1.2 Confidence in use of ICT

Read the 1.2.1 to 1.2.4statements below and indicate with an X where you rate yourself.

1.2.1 I am very confident about using ICT for professional purposes (e.g. preparation for class lessons)

Strongly disagree	Disagree	Agree	Strongly agree

1.2.2 I am very confident about using ICT in my teaching (e.g. with pupils)

Strongly disagree	Disagree	Agree	Strongly agree

1.2.3 I am very competent about using ICT for professional purposes (e.g. preparation)

Strongly disagree	Disagree	Agree	Strongly agree

1.2.4 I am very competent about using ICT in my teaching (e.g. with pupils)

Strongly disagree	Disagree	Agree	Strongly agree

1.3. Fill in the table below to indicate what equipment you have at home with which you can access the Internet (Put a tick in the appropriate column for each type of device)

	I have sole use of	I share with other people	I don't have access to
Desktop computer			
Laptop			
Tablet			
Mobile phone			
Games console			
Other device (please specify)			

1.4. What involvement did you have with the ICT integration project in your school?

2. ICT Integration project

2.1 How long has the ICT Integration project been going on?

Needs

2.2 Why did your school or science department decide to implement the ICT Integration project?

2.3 What was the ICT Integration project designed to achieve?

3. Plan

3.1 What planning/preparation took place before implementing the ICT Integration project? E.g. discussions with colleagues (in school or elsewhere), reading (online or offline), workshops you attended etc.

3.2 What barriers or obstacles did you anticipate there would be and how did you plan to overcome them?

4. Work undertaken in the Science Department

4.1 Describe how you rolled out the ICT Integration project in the Physical Science department (focusing on things that were different to what you had planned)

4.2 Were there any unexpected or surprising aspects to the implementation? (If so what were they?)

Lessons Learnt

5.1 What 'lessons' have you learnt from this ICT Integration project in Physical Science?

5.2 What would you do differently in the Physical Science department if you were starting to implement this ICT Integration project now?

5.3 What advice would you give to other Physical Science teachers who are starting off a similar ICT Integration project in their department?

Appendix A10: Summary of responses from the questionnaire instrument

SCHOOL	A	B	C	D	E	F
PSEUDONYM	Mr Ariel	Mr Johns	Ms Nomsa	Mr Khumo	Mr Zuva	Mr Sibeko
TYPE OF QUALIFICATION	Fitter & Turner Physical Science	BSC, PGCE	BSc (Hons), ACE	ACE Bed	BSC Environmental Science	Bed
EXPERIENCE IN ICT (YEARS/MONTHS)	5 years	10 years	10 Years	12 years	7 years	6 years

1.2. Confidence in use of ICT

CONFIDENCE IN USE OF ICT QUESTIONS	Mr Ariel	Mr Johns	Ms Nomsa	Mr Khumo	Mr S Zuva	Mr Sibeko
I am very confident about using ICT for professional purposes (e.g. Preparation for class lessons)	Strongly Agree	Agree	Strongly Agree	Agree	Strongly Agree	Strongly Agree
I am very confident about using ICT in my teaching (e.g. With pupils	Strongly Agree	Agree	Strongly Agree	Agree	Strongly Agree	Strongly Agree
I am very competent about using ICT for professional (e.g. Preparation)	Strongly Agree	Strongly Agree	Strongly Agree	Agree	Strongly Agree	Strongly Agree
I am very competent about using ICT in my teaching (e.g. With pupils)	Strongly Agree	Strongly Agree	Strongly Agree	Agree	Strongly Agree	Strongly Agree

1.3 Devices at home with which you can access the internet

Devices	Mr Ariel	Mr Johns	Ms Nomsa	Mr Khumo	Mr Zuva	Mr Sibeko
Desktop Computer	Have sole use	Don't have	Have sole use	Share with	Don't have	Have sole use

		access		other people	access	
Laptop	Have sole use (HP)	Have sole use	Have sole use	Have sole use	Have sole use	Have sole use
Tablet	Don't have access	Don't have access	Don't have access	Have sole use	Have sole use	Have sole use
Mobile Phone	Have sole use (Samsung)	Have sole use	Have sole use	Have sole use	Have sole use	Have sole use
Games console	Have sole use (PS2)	Don't have access	Don't have access	Don't have access	Don't have access	Have sole use
Other device (please specify)	Have sole use (Modem)	Don't have access	Don't have access	Don't have access	Don't have access	Have sole use: Projector DSTV PVR LED 3D TV LTE Connection

1.4

Name	**What involvement did you have with the ICT integration project in your school?**
Mr Ariel	I was given the equipment from Imperial and then told to prepare lessons.
Mr Johns	End User
Ms Nomsa	• Joined my school is 2013 and there were 2 years after implementing ICT in the school. • My involvement is in the Teaching & Physical Science & Record Keeping.
Mr Khumo	• I attended training workshops an ICT usage. • I am a bit advanced as I made some of colleagues who still struggle with ICT usage.
Mr Zuva	Develops consultant and trainer of staff for ICT Integration at the school.
Mr Sibeko	All, I am the school ICT Coordinator. I designed the program implemented in my school and also the policy.

2. ICT Integration Project

2.1

Name	**How long has the ICT Integration project been going on?**
Mr Ariel	2 years
Mr Johns	5 years
Ms Nomsa	2011 – 2015 but very slow (5 years).
Mr Khumo	Since January 2016.

Mr Zuva	7 years
Mr Sibeko	2 years

Needs

2.2

Name	Why did your school or Science Department decide to implement the ICT Integration project?
Mr Ariel	It was recommended.
Mr Johns	• Learners are more captivated. • Lessons are made exciting. • Lessons can be replaced, stored and modified. • An information back-up/bank is created. • Educator absence would not cause a lot of disruptions.
Ms Nomsa	• They were adopted by Sasol Inzalo as a school of focused learning. • ICT was one of the changes that educators had to adapt as part of the sponsorship package. • The government then supports us with computers as part of the Gauteng online project.
Mr Khumo	We are a pilot project by the MEC.
Mr Zuva	• Possibility to do simulations for learners. • Daily testing of learners is made easier. • Opportunity for learners to watch videos/animations explaining concepts.
Mr Sibeko	• To enhance the teaching and learning. • Improve efficiency of the planning. • Helping learners understand the work better.

2.3

Name	What was the ICT Integration project designed to achieve?
Mr Ariel	Maximum output from students.
Mr Johns	• Efficiency in lesson delivery. • Paperless environment. • Access to world class teaching materials. • Collaboration with other teachers in the field.
Ms Nomsa	• It was designed to improve the image of the school. • It was an incentive for teachers to have access to technology. • It was to improve school recordkeeping. • To improve communication. • To use in classes for teaching.
Mr Khumo	• To teach learners using ICT. • To produce learners who are knowledgeable in technology.

Mr Zuva	• Daily testing of learners. • Better understanding of concepts.
Mr Sibeko	• To help educators enhance the teaching and learning. • Help learners to learn more effectively. • Making science fun and exciting. • Targeting all learning styles.

Plan

3.1

Name	**What planning/preparation took place before implementing the ICT Integration project? E.g. discussions with colleagues (in school or elsewhere), reading (online or offline), workshops you attended etc.**
Mr Ariel	Time with Imperial weekend workshops
Mr Johns	• Discussing with project implementers. • Buying by educators and other stakeholders. • School visits. • Workshop's on the technology.
Ms Nomsa	• Sasol consulted with educators on types of laptops they wanted. • The connectivity issue was handled by Sasol Inzalo Foundation. • Training was made by Sci-Bono. • Training of 1-Box of Sangari South Africa. • Local educators helped too.
Mr Khumo	• We underwent training at an exemplary High School arranged by Matthew Goniwe School of leadership. • After training we looked at colleagues who are more advanced than others and they trained them internally. • We furthermore informed parents and had a training workshop with them so they can monitor learners tablet usage. • We trained learners on how to use the tablets.
Mr Zuva	• Attached school net conference. • Research in Learning Management Systems. • Training alone from Intel. • Training on Smartboards.
Mr Sibeko	• We had workshops. • We had meetings to discuss software that would work effectively. • Procedures to be included in the policy.

3.2

Name	**What barriers or obstacles did you anticipate there would be and how did you plan to overcome them?**
Mr Ariel	Writing on board had to use a PowerPoint that could be edited.
Mr Johns	• Resistance to use of computer educators' fear of the unknown.

	• Loss of equipment through theft etc. • Accessibility of this technology. • Learners' tend to avoid reading with to be enhanced by the use of technology. • High failure rate.
Ms Nomsa	• Theft – 3 tablets stolen in the first 3 months & 25 – 30 Desktops. • Security was up. • Training – surface training was done, but still educators not able to apply. • Caps aligned programs and provided by Sangari and Khami Academy.
Mr Khumo	• Resistance from colleagues (just a few). • We motivated the teachers that the ICT usage is for all of us not the MEC.
Mr Zuva	• Changing the attitudes of educators to implement ICT Training.
Mr Sibeko	• Costs for things like internet connections and repairs. • Security software is also expensive. • Teachers were not confident in using their tools and learners had no prior skills in using tech. • We attended workshops and gave workshops at our school. • We had daily support from competent staff. • Learners we slowly introduced to the technology. • We have yearly fundraisers to afford the costs associated with running ICT.

Work undertaken in the Science Department

4.1

Name	**Describe how you rolled out the ICT Integration project in the Physical Science Department (focusing on things that were different to what you had planned)**
Mr Ariel	The HOD and teachers in the know how seemed to have been leading
Mr Johns	• Identification of the right equipment and software. Some software was not adequate. • Per adjustment of software and equipment to meet requirement off the shelf materials were not adequate.
Ms Nomsa	• The school received laptops. • Signed for it. • Training was mostly done by Sangari on their I-box, but the rest one had to figure out. • Science educators help each other to get going.
Mr Khumo	
Mr Zuva	• Implementation of SMART boards in classes. • Implementation of tablets with e-boards • EPUBS – Not available yet – had to use PDF's • Implementation of learning management system. • Module – not function optimally: - Needs proper control and management.

	- The possibility of using alternative LMS's. - Cost of problem.
Mr Sibeko	• We first had a meeting to discuss how we were going to share the tablets and who will get interactive boards once funds are available. • We then set up a schedule to work with the tools and make turns. • We only used easy to learn software at the start that learners could use. • We slowly started to integrate more and more tools.

4.2

Name	**Were there any unexpected or surprising aspects of the implementation? (If so, what were they?**
Mr Ariel	None
Mr Johns	• Software was user friendly. • Some educators who had fears easily got attached to the software. • It made lessons easier & exciting.
Ms Nomsa	• Access to internet – learners seemed knowledgeable and would steal passwords and abuse the school facilities. • Educators on social media and live communication.
Mr Khumo	
Mr Zuva	• Yes, work becomes more effective. • Reporting functions of module became useful for support to learners. • Learners grasp concepts a lot faster than previous.
Mr Sibeko	• Yes, learners and teachers struggled to use the tools at first. • Learners had to be taught to look after and take care of the tools. • Some devices got broken due to lack of knowledge in working with it. • Our tablets got stolen from our safe in the first year. • This halted the progress of the program. • We started to implement our own tools after that.

5. Lessons Learnt

5.1

Name	**What 'lessons; have you learnt from this ICT Integration project in Physical Science?**
Mr Ariel	None
Mr Johns	• You don't normally get exactly what you expect when you buy equipment & software. • You always need to tailor made & modify equipment & software to meet needs. • Once the users buy into the project rollout is simple.
Ms Nomsa	• Require the principals & SMT be trained on how these facilities ought to managed.

	• Teachers require training, topic by topic according to Caps requirement & how mark sheets should be done.
Mr Khumo	• It makes learning interesting. • It makes teaching easy and interesting. • When you need some information you can google it on the internet. • There are lots of resources.
Mr Zuva	• Change takes time. • Proper training is needed. • Constant feedback from peer essential items of lessons being set up and used.
Mr Sibeko	• It's expensive and every teacher will have to make some financial sacrifices to make it work effectively due to funds. • Some schools will find it difficult to use the tools without a goof ICT Coordinator.

5.2

Name	**What would you do differently in the Physical Science Department if you were starting to implement this ICT Integration project now?**
Mr Ariel	I would go for more training and see which program best suite our school.
Mr Johns	• Get everyone's involvement. • It should not be made to seem like the project is parked down to us by management. • Take all suggestions with all the respect they deserve.
Ms Nomsa	• Train the Head of Department. • Train teachers on the role of ICT usage in P.S. • Call/invite ICT subject specialist and service providers for staff development.
Mr Khumo	
Mr Zuva	• More effective Learning Management System to be used. • Gradual integration from projectors – Smartboards & tablet use by learners.
Mr Sibeko	• Nothing, there will always be challenges and you deal with wit as it pops up. • It was a good learning experience.

5.3

Name	**What advice would you give to other Physical Science teachers who are starting off a similar ICT Integration project in their department?**
Mr Ariel	To combine Science, Maths, Technical before preparing lessons
Mr Johns	• Do a whole school education and identify needs. • Cut all stakeholders' support. • Train the end users.

Ms Nomsa	• Do not rush – seek advice. • One size fit all does not work – schools differ in locations and needs. • Choose /consult and find a good specialist from Khan Academy. • Partner with other schools that have more experience. • Consult for a fee from Doctors, Professors in the area for advice.
Mr Khumo	• They must be committed to the project. • There will always be some resistance, but once you are in, you are in; you will see how easy and interesting the ICT usage is.
Mr Zuva	• Do proper research. • Go for proper training that is based on the use of ICT in the classroom (Intel training for teachers) and SMARTBOARD training. • Ensure proper controlled internet access. • Use good Learning Management System that has proper support. • Take it step by step. • Start with laptop and Data projector and slowly build up to tablet integration over a few years.
Mr Sibeko	• Gain the necessary knowledge and skills to understand ICT. • Do lots of courses or workshops. • Get funds for the project and do fundraisers or meet with sponsors. • Start small; don’t rush to have it all at once. • Get some experience with each tool before moving to the next. • Plan for everything that can and will happen.

Appendix A11: Follow-up Questionnaire

School C: 0001

WSoE
Wits School of Education

Follow-up questionnaire

This case study is focussed on *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

The aim of this follow-up questionnaire is to make a follow up on the impression between the background to ICT integrated lesson planning, observed lessons and the completed questionnaire.

Pseudonym

- The spaces below are for taking notes in case the audio taping equipment malfunctions.

1. Do you think this ICT Integration project should continue?

2. If you answered YES to 1, how do you envisage it will develop?

3. If you answered NO to 1, why not?

3.2. Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?

4. Are there any factors that may help or hinder the continuation?

5. What impact has the ICT Integration project had on educator staff?

6. What impact has the ICT Integration project had on implementation of Caps in Physical Science in your school?

7. What impact has the ICT Integration project had on your pedagogy?

8. What impact do you think the ICT Integration project had on your pupils?

9. What other impacts has the ICT Integration project had?

Question 4 what are you asking in these questions? If nothing – delete 4-6

Authorized adaptation from Peter Twinning: Courtesy of Researchgate

Appendix A12: Summary of responses from the Follow-up Questionnaires

2.

Pseudonym	If you answered YES to 1, how do you envisage it will develop?
Mr Ariel	For all departments to be integrated into each other.
Mr Johns	• Should be inclusive so to cater for the whole school. • Data banks should be created for each subject. • Specific training for each subject so to give a better more focused use of ICT.
Ms Nomsa	• Help must be rendered where it is needed most – English / Afrikaans / Language areas. • Then technical and other subjects in order of priority. • Training must be given according to 1. • H.O.D. must go for content selection and materials they think best for their schools. • Schools must identify software and hardware negotiated /identified by the parent body / teachers / SMT & DBE.
Mr Zuva	• More user friend interactive content. • More integrated content in lessons – questions videos. • More content being used online. • More support out of classroom context.
Mr Khumo	
Mr Sibeko	• The future of ICT is not to replace teachers ICT is about access, anywhere learning and collaboration with others, both locally and globally. • Teaching and learning is social and schools in the future and with proper ICT could have a tradition of sharing and brainstorming ideas. • This will make learning faster and easier. • The classrooms of the future will have fast internet connections with wireless connection. • Learners can instantly share ideas with educators. • Homework and support materials can be sent to ICT devices. • ICT will have teaching today's generation fun & easy.

3.

Pseudonym	If answered NO to 1, why not?
Mr Ariel	
Mr Johns	
Ms Nomsa	
Mr Zuva	

Mr Khumo	
Mr Sibeko	

4.

Pseudonym	**Are there any factors that may help or hinder the continuation?**
Mr Ariel	To hinder, finance as well as SMT.
Mr Johns	• For continuation we will need. • Rapid resolution of problems encountered at implementation and evaluation stages. • Do? Problems, this will remove teacher frustration. • ICT Champions should be readily accessible and be well trained to resolve any issues. • Educators should be allowed and unlimited to use other resources for content environment whereby each teacher will have some ownership of content.
Ms Nomsa	• The principal & SMT lack of knowledge of what is required to plan forward. • Parent's participation being how. • Lack of enthusiasm from the teachers. • Incentives • Making CAPS ICT compliant & examinable.
Mr Zuva	• Limited internet access to teachers and learners. • Limited control from teacher on learners tablets. • Tablets need to be blocked for teaching purposes during certain times. • Help better Learning Management Systems/ classroom management systems.
Mr Khumo	
Mr Sibeko	• Lack of qualified teachers to teach using ICT in schools. • Lack of computers/tablets because of funds. • Lack of electricity in many areas and the current energy problems of SA. • Burglary keeping ICT safe in many schools is expensive and crime is high. • Teachers fear using ICT and have no confidence. • Anytime, anywhere access to teaching & learning materials. • Collaboration with like-minded people all over the world. • Can help prepare learners for a working world with tech. • Greater efficiency throughout the school. • Greater flexibility in when & where task are carried out. • Easier planning & preparation of lessons & support materials.

5.

Pseudonym	What impact has the ICT Integration project had on educator staff?
Mr Ariel	• Positive – advance in marks. • Negative – complains from staff that doesn't have it.
Mr Johns	• Increased self-esteem whereby the teacher is viewed as modern and in sync with current technological trends. • Will ensure that teachers are trendy and are using modern technology methods. • It will give teachers self-pride and eventually a better throughput. • Educators will be evaluated based on similar instruments not emotional peer-to senior evaluations.
Ms Nomsa	• Some have welcomed the initiatives especially the first beneficiaries. • Other members are of the view that those who use ICT are treated in high regard compared to those who do not.
Mr Zuva	• More effective teaching environment. • More interactive and collaborative work, but, this does take time.
Mr Khumo	• Most things are done electronically and we no longer carry many files. • An educator's file is in the laptop or USB.
Mr Sibeko	• At the moment none because it has not yet been properly integrated IMTD most schools. • Personally I use only ICT in lessons and I will not think of going back to the old ways. • I am giving higher quality lessons. • Learners are more focused on work and enjoy the lessons. • Due to my subject website, I collaborate with parents about homework & tests. • The learners get to see how the technology works & prepares them for the world. • Planning also became easier.

6.

Pseudonym	What impact has the ICT Integration project had on implementation of Caps Physical Science in your school?
Mr Ariel	Not sure
Mr Johns	• It has made teaching of waves, atomic theory, motion (mechanics) much easier for the teacher. • The learners were able to identify with abstract concepts.
Ms Nomsa	• Books – e-Books like siyavula easily accessible. • Past exam papers available. • Availability of already made lessons available.
Mr Zuva	• CAPS documentation instantly available on screen in front of you. • Better CAPS implementation through ease to copy and paste from CAPS documentation and resources.

Mr Khumo	• Most of our books are loaded on the SMART board. • You will never run out of space when you use the SMART notebook. • No PDNE anymore. • Textbooks loaded on the board are all CAPS aligned.
Mr Sibeko	• ICT makes it much easier to follow the CAPS Curriculum, but the ICT project that is current in working is not doing as much as it could. • ICT should be placed in the hands of qualified teachers that can plan and integrate it.

7.

Pseudonym	**What impact has the ICT Integration project had on your pedagogy?**
Mr Ariel	It has grown me
Mr Johns	• It was help me explain concepts in much better way. • It has helped me bring authentic experiences to the learners.
Ms Nomsa	• The structure of classroom management has improved - can sport the culprits/slow learners. • The rhythm of work is a little bit slow as slide has to be attended to. • Revision easy to do.
Mr Zuva	• Lessons more streamlined. • Explained conception 10 minutes that used to take 40 minutes. • More time to interact and assist learners individually. • Instant feedback on problems and quicker intervention on misinterpreted concepts.
Mr Khumo	• I can now use ICT to google information concerning the subject that I teach.
Mr Sibeko	• At the moment none. • The current integration project is not doing so well. • Personally use ICT continuously in my daily lessons and I can see a big change in learner's attitude towards learning.

8.

Pseudonym	**What impact has the ICT Integration project had on your pupils?**
Mr Ariel	• They have learnt a lot more no limits. • Marks have gone-up.
Mr Johns	• Better understanding of concepts and learners are kept captivated. • Learners are kept captivated more. • Learners want to do the subject. • Slow learners are able to ceilings and refer to presentations.
Ms Nomsa	• Pupils enjoy the lessons. • Learners can have access to the material. • Learners can repeat the lesson over and over without the educators.

	• Learners seem motivated as seen by their attendance level.
Mr Zuva	• More interest on subject matter and willingness team and interact with material.
Mr Khumo	• Learning is now interesting. • Little or absenteeism. • Learners are eager to learn. • Learners are committed to learning.
Mr Sibeko	• Learners are excited. • They communicate more. • Learners fund learning this way fun. • Marks increase.

9.

Pseudonym	**What other impacts has the ICT Integration project had?**
Mr Ariel	Fights for my class.
Mr Johns	• Assessments are real time based. The use of chickens has helped the situation. • Homework can be sent electronically and answers sent through the same medium. • Learner's cam do practice questions and get answers immediately.
Ms Nomsa	• Record-keeping is much easy. • Record retrieval is much faster. • Information dissemination is efficient and no learner can complain of inadequate work. • Self – Assessments available and no learner can complain of lack of assessments. • Parents can monitor learner activities by the number of log-ins
Mr Zuva	• Already answer previous questions. • Lighter bags of learners.
Mr Khumo	
Mr Sibeko	• The current ICT Integration problem has no noticeable impact on many schools. • In my personal class with my ICT, the learners can't wait to attend my class. • Lessons are fun and everyday new and exciting lessons get given. • It is easier to give lessons & keep the attention of learners for longer. • ICT also covers all learning styles. • Noticeable increase can be noticed due to learner's attention.

3.2

Pseudonym	Can you perhaps choose another Physical Science topic and describe how you would integrate ICT in its teaching?
Mr Ariel	• Research it. • Download videos from YouTube. • Choose a workshop best suiting the topic. • Create a PowerPoint Presentation. • Look at it as chess and anticipate questions and answers for students. • Show them practicals.
Mr Johns	• Atomic models – filling of orbitals. • I will use PHET program to build model's • Will give learners opportunities to build various atoms in the period table to the element calcium. • Learners will practice filling the orbitals and will learn the way orbitals are filled.
Ms Nomsa	• The Mole Concept: • Take Sangari CAPS aligned PowerPoints on mole concept. • Take Maths, Science and Marketing aligned Power Points on Mole Concept. • Arrange them in the order of how I want to teach the children/learners according to the CAPS Interpretation. • Play and replay the YouTube Videos selected as ground & effective for the mole concept lesson. • Self- Assessments Exercise. • Testing/Assessment. • Remedial.
Mr Zuva	• Electricity: - Series and parallel circuits. - Smmute test and Module – Terms electricity. - Video on series and parallel circuits. - Phet simulation – build a series and parallel circuit. - Presentation (PowerPoint). - Interactive table – draw using symbols. - Series or parallel circuit. - Build circuit on top of drawing. - Complete w/s giver.
Mr Khumo	• All our lessons are presented electronically.
Mr Sibeko	• ICT can be used in any subject. • Languages: Online Books • Story telling software • Using online dictionaries. Maths: Geometry Tools Online questions and problems Calculators software Games LO : Socializing Videos

	In NS –Tech all lessons can be integrated to use ICT in one form or another.

Why do you now have questions 4 and 5 after question 10?

Question 4

Pseudonym	
Mr Ariel	
Mr Johns	• ICT should not reduce teaching to watching and writing notes only. • Teachers should the opportunity to explain issues. • The Human Interface always makes a difference. • As much as ICT makes teaching and learning exciting, the educator should ensure that all learners are doing the same thing. • Learners may be engaging in other activities that are with related to the lesson.
Ms Nomsa	• Issues of theft: - Theft occurs of equipment but. - Learners and educator's pads have teachers and community members who monitor. - Equipment rooms ae well-secured.
Mr Zuva	
Mr Khumo	
Mr Sibeko	

Question 5

Pseudonym	
Mr Ariel	
Mr Johns	• ICT should help the learner to learn. • Simulations, demonstrations and experiments should be used to allow discover learning. • Learners should fold that the internet is not always the best source. • Library learners should check what they get from it. • The test book should not be thrown away.
Ms Nomsa	• Universities ought to come and help on new methods. • Re-skilling members and giving direction.
Mr Zuva	
Mr Khumo	
Mr Sibeko	

Appendix A13: LETTER TO THE PRINCIPAL and SGB

LETTER TO THE PRINCIPAL and SGB

DATE: 01/05/2015

Dear Principal and SGB

My name is Fumai Martin Mudindo. I am a Masters Student in the School of Education at the University of the Witwatersrand.

I am doing research on *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

My research involves observing educators integrating ICT during the teaching process, educators completing a questionnaire and finally conducting an oral audio-taped interview with them.

The reason why I have chosen your school is because it is involved in the integration of ICT in Mathematics and Science teaching projects.

It would be greatly appreciated if your school would allow me to conduct my research with your learners and members of staff.

The research participants will not be advantaged or disadvantaged in any way. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

The names of the research participants and identity of the school will be kept confidential at all times and in all academic writing about the study. Your individual privacy will be maintained in all published and written data resulting from the study.

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

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Fumai Martin Mudindo

NAME: Fumai Martin Mudindo
ADDRESS: John Orr Technical High School
EMAIL: mfumai @yahoo.com
TELEPHONE NUMBERS: 060 439 4345

Appendix A14: INFORMATION SHEET FOR LEARNERS

INFORMATION SHEET LEARNERS

DATE: 01/05/2015

Dear Learner

My name is Fumai Martin Mudindo and I am a Masters Student in the School of Education at the University of the Witwatersrand.

I am doing research on *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

My investigation involves observing educators teaching the topic on Mechanics using ICT.

I kindly invite you to voluntarily participate in this study.

I will not be using your own name at any given time and so no one can identify you. All information about you will be kept confidential in all my writing about the study. Also, all collected information will be stored safely and destroyed between 3-5 years after I have completed my project.

Your parents have also been given an information sheet and consent form. I look forward to working with you!

Please feel free to contact me if you have any questions.

Thank you

SIGNATURE Fumai Martin Mudindo

NAME: Fumai Martin Mudindo
ADDRESS: John Orr Technical High School
EMAIL: mfumai@yahoo.com
TELEPHONE NUMBERS: 060 439 4345

Appendix A15: Learner Consent Form

Learner Consent Form

Please fill in the reply slip below if you agree to participate in my study called:

Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.

My name is: Fumai Martin Mudindo

	Circle one
Permission to observe you in class	
I agree to be observed in class.	YES/NO
Permission to be audio-taped	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

Appendix A16: INFORMATION SHEET PARENTS

INFORMATION SHEET PARENTS

DATE: 01/05/2015

Dear Parent

My name is Fumai Martin Mudindo and I am a Masters Student in the School of Education at the University of the Witwatersrand.

I am doing research on *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

My research involves observing how educators integrate ICT during the teaching process.

The reason why I have chosen your child's class is because the educator is involved in the integration of ICT in Science teaching.

It would be greatly appreciated if your child would be part of the class being observed.

Your child will not be advantaged or disadvantaged in any way. The learners will not be identified in any way. There are no foreseeable risks in participating and your child will not be paid for this study.

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

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,

SIGNATURE: Fumai Martin Mudindo

NAME Fumai Martin Mudindo
ADDRESS John Orr Technical High School
EMAIL mfumai@yahoo.com
TELEPHONE NUMBERS: 060 439 4345

Appendix A17: Parent's Consent Form

Parent's Consent Form

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

Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.

I, ________________________ the parent of ______________________

Circle one

Permission to observe my child in class **YES/NO**

I agree that my child may be observed in class.

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.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign_____________________________ Date___________________________Appendix A25:

Appendix A18: INFORMATION SHEET TEACHERS

DATE: 01/05/2015
Dear Educator:

My name is Fumai Martin Mudindo and I am a Masters Student in the School of Education at the University of the Witwatersrand.

I am doing research on *Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.*

My research involves observing educators integrating ICT during the teaching process, educators completing a questionnaire and finally I will audio-tape an interview with them.

The reason why I have chosen your school is because it is involved in the integration of ICT in Mathematics and Science teaching projects.

I was kindly inviting you if you may voluntarily participate in this study.

Your name and identity will be kept confidential at all times and in all academic writing about the study. Your individual privacy will be maintained in all published and written data resulting from the study.
All research data will be destroyed between 3-5 years after completion of the project.
You will not be advantaged or disadvantaged in any way. Your participation is voluntary, so you can withdraw your permission at any time during this project without any penalty. There are no foreseeable risks in participating and you will not be paid for this study.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely, **SIGNATURE Fumai Martin Mudindo**
NAME Fumai Martin Mudindo
ADDRESS John Orr Technical High School
EMAILmfumai@yahoo.com
TELEPHONE NUMBERS: 060 439 4345

Appendix A19: Teacher's Consent Form

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called:

Educators' integration of ICT in teaching Mechanics in grade 10 Physical Sciences in three South African High Schools.

I, ________________________ give my consent for the following:

Circle one

Permission to observe you in class

I agree to be observed in class.
YES/NO

Permission for questionnaire

I agree to complete the questionnaire for this study.
YES/NO

Permission for an audio-taped interview

I would like to be audiotaped during the interview for this study. YES/NO

I know that I can stop the interview at any time and don't have to
Answer all the questions asked. YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date___________________________

Appendix A20: CAPS DOCUMENT on Mechanics

Work schedule : PHYSICAL SCIENCE GRADE: 10 CAPS

TERM: 3/2016 KNOWLEDGE AREA: PHYSICS - MECHANICS

% cumulative completion	Week	Time frame			Content, Concepts and Skills	Practical activities	Date completed & signature
71,2 %	28	22 - 26 Aug **5 days**	4 hours	**Vectors and scalars** Introduction to vectors & scalars.	❑ **List physical quantities** (time, mass, weight, force, charge etc.) ❑ **Define** and **differentiate** between: **vector** and a **scalar** quantity. ❑ **Understand**: • $\vec{F}$ represents the force vector • F represents the magnitude of the force vector ❑ **Graphical representation** of vector quantities. ❑ **Properties of vectors**: equality of vectors, negative vectors, addition, subtraction and multiplication of vectors (use force vector) ❑ **Define resultant vector**. ❑ **Find** resultant vector: • **graphically** (tail-to-head method) and • by **calculation** using a maximum of four force vectors (1D)		

Work schedule : PHYSICAL SCIENCE GRADE: 10 CAPS

				Motion in one dimension:			
74,4 %	29	29 Aug – 2 Sept **5 days**	4 hours	**Reference frame, position, displacement and distance**	❑ **Describe** concept of a frame of reference - origin and a set of directions e.g. East and West or up and down. ❑ **Define**: • one dimensional motion • position - relative to reference point , can be positive or negative • distance - scalar quantity • Displacement (*change in position, vector quantity that points from initial to final position.*) ❑ **Know** and illustrate difference between displacement & distance ❑ **Calculate** distance and displacement for one dimensional motion	**Practical Demonstration**: 1. Use a long straight track, a curved track, a toy car and a meter rule to illustrate the concept of position, distance and displacement. 2. Make cardboard arrows to represent vector quantities.	

% cumulative	Week	Time frame			Content, Concepts and Skills	Practical activities	Date completed & signature
80,8 %	30 - 31	5 - 16 Sept **10 days**	5 hours	**Average speed, average velocity, acceleration**	❑ Define **Average …**: • Speed (*distance travelled divided by the total time, scalar quantity)* • Velocity *(displacement (or change in position) divided by the time taken, vector quantity)* • Acceleration (*change in velocity divided by the time taken*) (acceleration provides no info about the direction of motion; it only indicates how the motion (velocity) changes) ◆ Differentiate between positive acceleration, negative acceleration and deceleration ❑ Calculate **Average …**: • speed • velocity for one dimensional motion ❑ Convert between different units - speed & velocity, ($m.s^{-1}$, $km.h^{-1}$)	**Experiment**: Measurement of velocity	
			3 hours	**Instantaneous velocity, instantaneous speed**	❑ Define **instantaneous**: • **velocity** (*displacement (or change in position) divided by an infinitesimal (very small) time interval*), vector quantity • **speed** (*magnitude of the instantaneous velocity*)		
					CONTROLLED TEST 2		

GAUTENG PROVINCE

Work schedule : PHYSICAL SCIENCE GRADE: 10 CAPS

Department: Education

% cumulative	Week	Time frame			Content, Concepts and Skills	Practical activities	Date completed &
	Instantaneous speed and velocity and the equations of motion.						
87,2 %	32 - 33	19 – 30 Sep **10 days**	6 hours	**Description of motion in words, diagrams, graphs and equations.**	❑ Describe: ◆ in words and distinguish between motion with uniform velocity and uniformly accelerated motion. ◆ the motion of an object given its position vs time, velocity vs time and acceleration vs time graph ❑ Determine the : ◆ velocity of an object from the gradient of the position vs time graph. • Know that the slope of a tangent to a position vs. time graph yields the instantaneous velocity at that particular time. ◆ acceleration of an object from the gradient of the velocity vs time graph. ◆ displacement of an object by finding the area under a velocity vs time graph. ❑ Calculate: ◆ Use the kinematics equations to solve problems involving motion in one dimension (horizontal only). $v_f = v_i + a\Delta t$ $\Delta x = v_i\Delta t + ½a(\Delta t)^2$ $v_f^2 = v_i^2 + 2a\Delta x$ $\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ❑ Demonstrate an understanding of motion of a vehicle and safety issues, such as the relationship between speed and stopping distance		
					Recommended project for formal assessment: **Acceleration** 1. Roll trolley down inclined plane with a ticker tape attached to it & use the data to plot a position vs. time graph. a. Vary angle of inclination b. Keep angle fixed and use inclined planes, use different materials on surface		

Work schedule : PHYSICAL SCIENCE GRADE: 10 CAPS

TERM: **4/2016** **KNOWLEDGE AREA:** **PHYSICS - MECHANICS**

% cumulative completion	Week	Time frame			Content, Concepts and Skills	Practical activities	Date completed & signature
	Energy:						
93,6 %	34 - 35	10 - 21 Oct **10 days**	1,5 hrs	**Gravitational potential Energy**	▫ **Define gravitational potential energy** of an object (*energy it has because of its position in the field relative to some reference point.*) ▫ **Determine** the gravitational potential energy of an object using $E_P = mgh$	**Practical Demonstration**: Conversion of Energy (qualitative	
			1,5 hrs	**Kinetic energy**	▫ **Define** kinetic energy (*energy an object possess as a result of its motion*) ▫ **Determine** the kinetic energy of an object using $E_K = ½mv^2$		
			1 hr	**Mechanical energy (E_M)**	▫ **Define** mechanical energy *(the sum of the gravitational potential and kinetic energy.)* ▫ **Use** equation: $E_M = E_K + E_P$		
			4 hrs	**Conservation of mechanical energy (in the absence of dissipative forces).**	▫ **State**: ◆ The **law** of the **conservation of energy** ◆ That in the absence of air resistance, the mechanical energy of an object moving in the earth's gravitational field is constant (conserved) ▫ **Apply** the **principle** of conservation of mechanical energy to various contexts (objects dropped or thrown vertically upwards, the motion of a pendulum bob, roller coasters and inclined plane problems) ▫ **Use** equation: $E_{K1} + E_{P1} = E_{K2} + E_{P2}$		

END OF TERM 3 **DUE DATES FOR:**

Informal Assessment - Monthly test:	29 July 2016
PROJECT (hand in)	12 August 2016
Informal Assessment - Monthly test:	19 August 2016
Controlled Test 2	16 September 2016

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