

https://dspace.org/

The B.E.D. science programme and how it prepares student teachers to teach practical work in schools during teaching experience

Choonara, Yasmeen

2017

http://hdl.handle.net/10539/23506

Choonara, Yasmeen (2017) The B.Ed Science programme and how it prepares student teachers to teach practical work in schools during teaching experience, University of the Witwatersrand, Johannesburg, http://hdl.handle.net/10539/23506

Downloaded from a DSpace repository. https://dspace.org/

The B.Ed. Science programme and how it prepares student teachers to teach practical work in schools during teaching experience



Yasmeen Choonara

0109150e

A Research project submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of MSc.

10 May 2017

Declaration

I confirm that this research is the result of my own work. Other sources I have referred to can be found listed in the references. This research has not been submitted for examination elsewhere.

Yasmeen Choonara

_____

10 May 2017

Abstract

This study seeks to investigate how the B.Ed Physical Science laboratory work program prepares student teachers to handle laboratory work in schools during teaching experience. Experimentation is what separates the scientific disciplines from other disciplines in the school curriculum, yet research has shown that in many schools teachers are not carrying out laboratory work (Wilkinson & Ward, 1997). The few practical's that are carried out are demonstrations that are targeted at meeting the basic science curriculum requirements. While some researchers (Dillon, 2008; Langley, 2014; Toplis, 2011; Wilkinson & Ward, 1997) have argued that teachers in schools have little time and resources available for meaningful laboratory work, due to unwieldy and rigid curriculum, other researchers (Hodson, 2007; Staer et al., 1995; Abd-El-Khalick & Lederman, 2000) point out that the problem could equally be that the teachers lack the practical skills themselves, to carry out laboratory practical work, let alone, training their students to do the same.

This study, will therefore investigate how well B. Ed 4th year Physical Sciences students have been prepared to run practical's as pedagogical tools for motivation, modeling scientific practice, teaching about the nature of science and acquiring manipulative skills necessary for the handling and usage of scientific equipment.

Acknowledgements

I firstly and mostly want to thank God for helping me through this difficult time and allowing me to pursue my dreams.

I am indebted to my supervisor Dr Emmanuel Mushayikwa for the advice and assistance rendered during the course of this research. His guidance and support and encouragement was most appreciated.

I am also grateful to all the students, teachers, technician and lecturers who gave up their time and schedules to answer my questionnaires and participate in my interviews. I regret that I cannot mention them by name.

Last but not least I want to thank my friends Parishka, Climant, Jakie, Aviwe, Thabo, Kabelo and Thandiwe for their continued encouragement and helpful ideas on my topic.

To my dearest angel in heaven, My Son, who was my source of inspiration and encouragement to get me through this difficult time. To my family who stood by me and sacrificed their time to accommodate me thank you.

Table of Contents

Abstract 3

Declaration 2

Acknowledgements 4

Chapter 1: Introduction to the study

- 1.1 Introduction 7
- 1.2 Context of the study 7
- 1.3 Rationale 8
- 1.4 Problem statement 9
- 1.5 Purpose of the study and research questions 10
- 1.6 Conclusion 10

Chapter 2: Literature review and theoretical framework

- 2.1 Introduction 12
- 2.2 Aims of the South African Curriculum 12
- 2.3 History and Philosophy of Science 16
- 2.4 Views on practical work and factors that inhibit practical work 18
- 2.5 Language and practical work 21
- 2.6 Theoretical perspectives and inquiry-based learning 25
- 2.7 Conclusion 29

Chapter 3: Literature Review

- 3.1 Introduction 30
- 3.2 Sampling and participants 31
- 3.3 Data collection and instruments 31
- 3.4 Data analysis and interpretation 33
- 3.5 Ethical considerations 34
- 3.6 Research rigour 35
- 3.7 Conclusion 35

Chapter 4: Analysis of Results and Discussions

4.1 Introduction 36

4.2 What is it that the Lecturers say about the objectives of the Physical Science IV course. 36

4.3 What practical activities are carried out by pre-service teachers? What is the importance of those practical activities according to the pre-service teachers. 39

4.4 What are the perceptions of B.Ed 4th year physical science teachers with regards to practical activities during their teaching experience? 45

4.5 How are practical skills transferred from B.Ed to a school context. 47

4.6 Summary 54

4.7 Conclusion 54

Chapter 5: Conclusion

5.1 Introduction 58

5.2 Summary of results 58

5.3 Limitations of the study 61

5.4 Recommendations and future research 61

5.5 Efficiency of Research Design

References 62

Annexures 73

Chapter 1: Introduction to the study

1.1 Introduction

Much research has been done about learners and teachers' perceptions of practical work and a lot of research has been done on the purposes of practical work. However, Hodson (1996) found that there is limited engagement taking place in practical work and it was more like following a recipe rather than understanding what was being done. In South African Schools, despite the aims and objectives that are outlined in the CAPS document, it is still a challenge for some teachers to carry out this practical work. Ramnarain (2011) did research in South African schools and found that practical work lacks the freedom to inquiry and experiment which results in teachers' demonstrating and using 'cookbook recipes' where learners' follow instructions given by the teacher. Many teachers still use common approaches which consist of traditional experiments which is more illustrative than enquiry based (Villanueva & Webb, 2008). Due to this approach of guiding learners, many teachers find it difficult to implement CAPS as the expectations as mentioned in the document are more demanding then following instructions. These expectations involve "Practical investigations and experiments should focus on the practical aspects and the process skills required for scientific inquiry and problem solving. Assessment activities should be designed so that learners are assessed on their use of scientific inquiry skills, like planning, observing and gathering information, comprehending, synthesising, generalising, hypothesising and communicating results and conclusions. Practical investigations should assess performance at different cognitive levels and a focus on process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts" (Department of basic Education, 2011, pp 144).

1.2 Context of the study

Curriculum reforms that is the NCS (National Curriculum Statement), RNCS (Revised National Curriculum Statement) and CAPS (Curriculum Assessment Policy Statement) came up with ways of moving away from the traditional rote teaching and learning to more interactive ways of teaching and learning. One of the strategies recommended by Abrahams & Millar (2008) is to ensure more active engagement of learners is through engaging learners in practical work. The South African Science curriculum requires learners to engage in practical work. One of the specific aims in CAPS physical sciences is that learners should be

able to carry out investigations and experiments (Department of basic Education, 2011). Practical work is part of the curriculum as mentioned above yet according to Hodson (1991), even though practical work is practiced in some schools; it is still ill-conceived, confused and seen as unproductive by teachers.

My research is based in the Wits School of Education and 6 schools that the B.Ed physical science 4th year student teachers attending for teaching experience. These pre-service teachers major subject is Physical Science. Looking at the context of the schools, they are all government schools situated in Johannesburg and 1 school in the Vaal. The schools consist of a mix of learners. The schools were chosen by the students.

1.3 Rationale

How can we expect learners to be the future scientists when teachers' are failing to teach the skills of science. Ogunmade (2005) argues that teachers lack motivation, lack of resource materials, infrastructure is poor, negative attitude of learners'towards science and lack of teaching skills and competency in the subject matter. The reason for doing this research was to argue that practical work improves teaching physical science and it will clarify the importance of linking theory to the practical part of it. This study could be used as a foundation to improve the B.Ed practical science 4th year program by finding the gaps and also assist in the curriculum as some teachers refrain from practical work as they are not confident enough or do not have the knowledge and skills as well as support. According to Abrahams and Millar (2008), the house of commons Science and technology commented (2002) that in their view, "practical work, including fieldwork, is a vital part of science education". Practical work assists students to develop their understanding of science and appreciate that science is based on factual evidence and acquires skills such as manipulative skills which are important (Langley, 2014) in order to progress in experimental and investigative work (Abrahams & Millar, 2008).

Abrahams and Millar (2008) further argue that the current setup of laboratory work contributes little to learning. However, as seen in Figure 1.1, practical work is the foundation of getting learners interested and active in the science community of practice. It is all about motivation, linking theory with practical work, development of manipulative skills and the nature of science. Through practical work, learners are able to implicitly understand the nature of science and how scientists function. It is all about taking the theory and applying it

in everyday situations and also looking at the relevance of skills acquired to challenge present technology. Figure 1.1 shows the gap that exists in pre-service teachers when it comes to their preparation for teaching practical work. It shows how this study contributes to understanding practical work by pre-service teachers in their teacher training program.

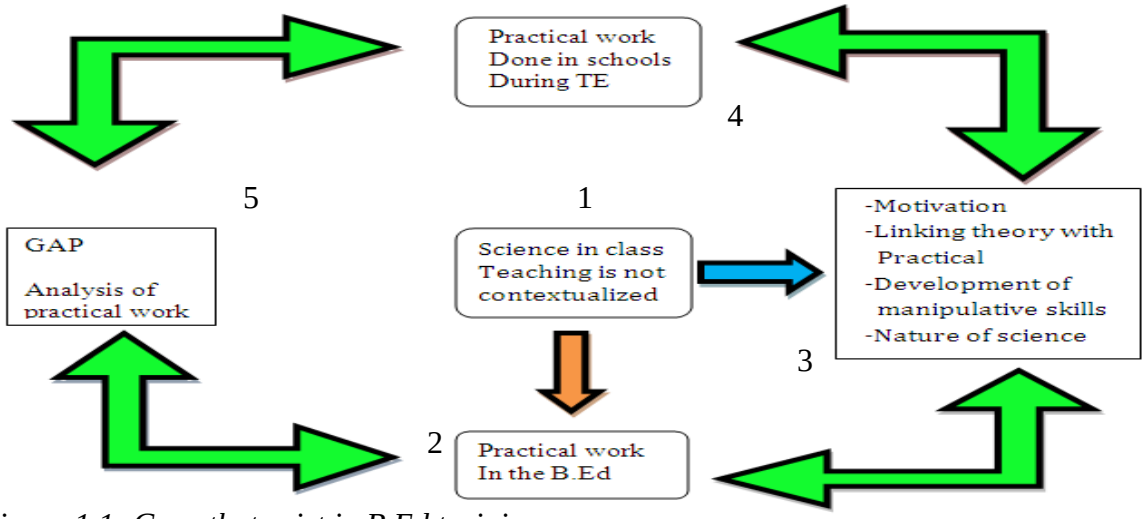


Figure 1.1: Gaps that exist in B.Ed training

1.4 Problem Statement

The fundamental purpose of practical work in school science is to help students make links between the real world of objects, materials and events and the abstract world of thought and ideas (Abrahams & Millar, 2008; Brodie, 1978; Millar, 2004). The purpose of practical work is viewed differently by teachers and student teachers. In the B.Ed program practical work is examined whereas in schools practical work is not examined but assessed. This assessment is not adequate as most of the learners work in groups and share results due to a lack of equipment. For the B.Ed practical work examination is a good way to check that student teachers have acquired the requisite skills necessary to conduct practical work in their own schools upon graduation.

As a laboratory demonstrator within a teacher education institution, I have seen the changes and development that take place from a first year to a fourth year physical science student. From students who have never been in a laboratory to students who have always worked with equipment. However, I still feel more could be done to prepare our students for the reality of

school life. As a student teachers going on teaching experience I used to be preoccupied with the need to impress my tutors by designing creative lessons. However, as an actual classroom teacher, one does not get the time for such creativity. One can argue that a student teacher no matter how detailed the lesson plan can be at a university level when they face real challenges of the classroom, they often abandon new practices and revert to the teaching methods their teachers used (Mji & Makgato, 2006). When we look at the B.Ed 4th year course we want to see what the course offers to assist students to carry out practical work in schools confidently and also to motivate learners' to choose physical science. We then look at that transformation of theory and practical work acquired in the B.Ed 4th year course and how it is transferred in schools to the learners'. In schools we look at what practical work is being done and is it being done as well as why those practical experiments were chosen by the student teacher and how it is planned for. The problem here is that students do not seem to implement what they learn in the university. Research has shown that students can do practical work themselves at their university levels (Hodson, 2009) but teaching learners through practical work is still a challenge. One could pose a question on how these pre-service teachers were trained. This is what I wanted to understand while taking into consideration their perceptions.

1.5 Purpose of the study and Research Questions

The primary purpose of this study is to investigate how pre-service teachers transform their practical skills that they learn in the University to the school context during their practice.

The study was guided by the following research questions:

1. What is it that lecturers say about the objectives of the Physical Sciences IV course?
2. What practical activities are carried out by pre-service teachers? What is the importance of these practical activities according to the pre-service teachers?
3. What are the perceptions of B.Ed 4th year Physical Science teachers with regards to practical activities during their teaching experience?
4. How are practical skills transferred from B.Ed to a school context?

1.6 Conclusion

This chapter aimed at providing the reader with the introduction and background of the study. The study is generally based on using practical work in science as a way of enhancing learner understanding. I started by providing the context of the study and locating the study within

the South African curriculum by arguing on the necessity of practical work. I then argued that this study is significant for teachers to notice their practical work skills and how their skills can actually enhance learner understanding. I then looked at the problem statement and argued that practical work is still not taken seriously in many science classrooms and that teachers are still not competent enough to run practical lessons. I finally presented research questions and stated that the purpose of the study was to look at how pre-service teachers are prepared to teach practical work in their teaching experience.

This report consists of five chapters. The first chapter deals with the introduction and background to the study. In the second chapter, I deal with the theoretical framework and literature review. I then move to chapter 3 where I deal with the methodology and research design of my study. Chapter 4 looks at the analysis of the data, research findings and discussions around those particular findings. I then conclude the study in chapter 5 by summarizing the findings to the research questions and also looking at some recommendations and implications emerging from the study.

Chapter 2: Literature Review and Theoretical Framework

2.1 Introduction

Today's science education offers an opportunity and necessity for including a wide variety of instructional activities. As science teachers we look for every opportunity to adopt ideas that we see, hear, or read about that would add a spark to our regular lesson. It is easier for learners' to understand concepts that they can experience hands-on. Taking part in laboratory activities is considered to be an important activity for all science learners to engage in. However, learners from disadvantaged backgrounds have fewer opportunities. Gega (1990) notes that science teaching is more understandable when linked to things that can be seen. Practical work encourages learners to engage with the process of learning and thereby promotes positive student attitudes. Loucks-Horsely et al., (1990) argue that science education should give children an opportunity to explore how things work firsthand, through activities and experiences with a wide variety of materials.

In this chapter, I deal with literature review and theoretical framework. I start by looking at the aims of science in the South African curriculum and how these aims are met or not met for the purposes of learner understanding. I then look at the history and philosophy of science and how this is linked to practical work. I then argue for the purpose of practical work in science together with views on practical work. I then discuss how language and other factors can enhance or hinder the acquisition of science concept in practical work. I finally explain theoretical perspectives which guided my study.

2.2 Aims of the South African CAPS curriculum

Generally, the aims of science education can be summarized as follows: (1) to help students to gain an understanding of as much of the established body of scientific knowledge as is appropriate to their needs, interests and capacities and (2) to develop students' understanding of the methods by which the knowledge has been gained and our grounds for confidence in it (Millar, 2004). As laid down in the Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2011a), there are prescribed practical activities for grades 10 to 12 that emphasize integration of practical work with classroom theory-based science teaching (Department of basic Education, 2011a). Because these practical activities are prescribed, teachers have a choice of doing alternatives based on the availability of resources.

However, it looks like the availability of resources does not make much difference. Teachers who have resources in their schools do not engage in practical work because they just do not have the necessary skills for that. Teachers expect learners to be able to do experiments carry out investigations and do projects as part of their assessment but they themselves need to be confident and skilled when carrying out experiments.

Pekmez, Johnson and Gott (2005) view practical work in a positive manner whereby it helps and assists with the development of skills. Perkins-Gough (2007) looked at practical work as a development of team building. One of the objectives of the Science 4th year course is for students to collaborate and work as a team. This is something that "The National Curriculum Statement Grades R to 12 aims to produce learners that are able to work effectively as individuals and with others as members of a team" (Department of Basic Education, 2011a, pp. 5).

It is necessary to compare and argue that the school program and the BEd 4th year programme are similar in some aspects but at the same time differ with regards to aims and objectives. Let's take a look at the BEd 4th year program. (Annexure 2) States clearly the objectives of the BEd 4th year program and how this program emphasized on trying to perfect their skills and content learnt as well as growing there confidence in doing practical work without hesitation or fear. When looking at the CAPS document page 9 and 11 (Annexure 3) the specific aims of physical sciences is not as explicit as the BEd 4th year. The specific aim is more to equip learners for a career that involves physical science whereas the BEd 4th year is part of a degree choice in science education which is science specific. The overview of practical work mentioned in the CAPS document page 11 (Annexure 3) clearly states that the reason for practical work is to link theory and practical. The BEd 4th year and CAPS both align with the aim to link theory and practical but the BEd 4th year goes on to master those skills beyond a classroom environment in order to enhance the quality of students' learning and to promote job satisfaction once they have qualified.

Researchers like Abrahams and Millar (2008) argue that teachers are not implementing practical work. This view is however countered by Akinbobola and Afolabi (2010) who believe that the acquisition of science skills is an important indicator of transfer of knowledge which is necessary for problem solving and functional living. Again, this is what the CAPS curriculum strongly encourages (Department of Basic Education, 2011a, pp.8) The CAPS document has practical work in a form of practical experiments, investigations,

demonstrations and projects (Department of basic Education, 2011a, pp.11 section 3). The activities (see Annexure 3) are meant to develop problem solving skills and scientific inquiry. Skills such as observation, manipulation, analysis, data collection are being a seen as important. The CAPS document also stipulates that practical work has to be "integrated with theory to strengthen the concepts being taught" (DoE, 2011, p11).

In South African schools, the implementation of CAPS, with regards to practical work in science, seems to be a challenge for both learners and teachers looking at the practical part of it. Ramnarain (2011) found that in South African schools, most teachers opted to teach using demonstrations instead of experiments which require learners to deal with apparatus because of shortage of equipment. Even where equipment was available, teachers claimed that asking learners to do practical work was a waste of time as they had a lot of curriculum content to cover. In some instances, teachers themselves lacked the confidence to carry out practical experiments, and they frequently complained of lack of support from the department. The argument about lack of adequate time to do practical work has also been raised by Abrahams and Millar (2008) in the UK. They observed that teachers used 'recipe style' tasks instead of open-ended investigations because they did not have sufficient time. Many studies have shown according to Clackson and Wright, (1992); Kirschner, (1992) and Abraham and Millar (2008) that learners do what teachers ask of them and the most common practical work followed is that of a 'recipe' style. Follow the recipe get the expected results and write a report that most of the time is done step by step by the teacher.

Much is known about the prescribed practical work in the CAPS document but very little effort has been made into actually carrying out this practical work as some schools in South Africa are equipped while others, mainly in rural areas do not have the apparatus or laboratories to conduct this practical work. It is not only the underprivileged schools that do not conduct practical work but schools that do have the equipment also seem to refrain from practical work due to time and the lack of meaningful use and skills of practical work (Hodson, 1990; Stoffels, 2005; Toplis & Allen, 2011).

Recognizing that practical work has always been an integral part of engaging learners to concrete learning experiences in science classrooms (Hofstein & Lunetta, 1982), the South African schooling curriculum, assesses practical work through coursework. However, the practical work in schools is marked by using rubrics and right or wrong answers (Annexure

3). Therefore, this denies learners the opportunity to carry out open-ended investigations where they can explore different things.

Bennet (2003) defines enquiry based teaching as the art of developing challenging situations in which students are asked to observe and question phenomena, pose explanations of what they observe, devise and conduct experiments in which data are collected to support or contradict their theories, analyze data, draw conclusions from experimental data, design and build models, or any combination of these. Such learning situations are meant to be open-ended in that they do not aim to achieve a single 'right' answer for a particular question being addressed but rather involve students more in the process of observing, posing questions, engaging in experimentation or exploration and learning to analyze and reason". By this definition we can argue about the approach to practical work in the CAPS document and the challenges teachers are faced with. Villanueva and Webb (2008) support the ineffectiveness of these inquiry based activities if not supplemented with minds-on activities that is writing and reading tasks that is facilitated, keeping them focused. According to Hurd (1969), the importance of practical work is to develop cognitive skills and practical work problems need to be approached using inquiry processes.

Abrahams and Reiss (2012) emphasize the effectiveness of specific practical tasks, rather than practical work in general. This means that each practical task must have an objective and must be chosen for a reason to be part of the CAPS document. Abrahams and Millar (2008) mention that laboratories play an important role in a learner's learning experience and this factor should encourage learners to pursue science at tertiary levels. By being in a laboratory Abrahams (2009) refers to it as 'situational interest' which refers to the environment or situation students are in. However, if this laboratory work is not done by learners or not done at all, how can we then expect learners to even know what communities of science entails and how their knowledge and skills can be used to improve the economy and develop technology for the future?

Ramnarain and Fortus (2013) conducted a study to determine 'South African Physical Sciences teachers' perceptions of new content in a revised curriculum' found that teachers mainly covered syllabus for examinations purposes and this involved rote learning as learners do not have the time to apply the knowledge practically. Schools thrive on exam pass rates but even though they claim to develop learners to learn each and every domain, the schooling communities are still unable to produce practitioners in every domain. Schooling

communities preach that learners should solve problems. These problems can be solved as "just plain folks" (Brown et al., 1989) but in schooling communities these solutions will not be accepted as learners are provided with certain tools to solve specific problems that will not be relevant to normal situations in the world but rather "textbook" problems. Learners in schooling communities are just learning about subjects and not directly engaging with the subject itself. If this engagement is not used effectively, then there won't be any learning (Lave & Wenger, 1991).

2.3 History and Philosophy of Science

What is the History and Philosophy of Science? HPS (History and Philosophy of Science) "focuses on the historical development of science that learners should know as long as they learn science in a historical context, the focus of teaching acquisition to understanding the process of doing science" (Hottecke, 2010, p.4). It is therefore important that teaching science incorporates the history and philosophy of science. More specifically practical work should reflect the philosophy of science which is manifested in the nature of science. Nature of science is all about linking the real world with everything around them.

By mentioning scientists and their achievements learners are able to understand how the concept began or can trace back what scientists did and how science has improved to what they are exposed to today. Hottecke (2010) states that the knowledge from the past is very important as it forms the foundation of what we know now. Furthermore, it guides our understanding of the current knowledge and the importance of practical work in the scientific community. HPS is focused on learner-centered activities like "experimenting, making observations, discussing and role-play, a variety of open-ended methods of teaching and learning science" (Hottecke, 2010 p4). It is important to incorporate it in science teaching and practical work because it stimulates learner's interest by discussions and sharing ideas as well as generating and evaluating scientific evidence among the learners. Learners must appreciate the role of historical concepts and knowledge for their own learning (Hottecke, 2010). By engaging learners in practical work they are able to acknowledge the evolution of scientific knowledge as well as the concepts discovered which explains the history and philosophy of science.

HPS materials must relate to the concept being taught and used appropriately. Instruction is a key point in HPS which must be made clear to learners on HPS materials and verbal

instruction in the class. Learners are expected to appreciate that there are questions to ask and to begin to think not just about answer, but what would count as answers, and what kinds of evidence would support our answers (Matthews, 1992). These new teaching materials allow teachers to question learners differently in class and in an assessment. The expectation of learners' is that they are able to answer questions that involve theory application and calculation as well as everyday incidents that happen and how that would go about investigating what happened during the car crash that caused the damage and what could have been done to save the passengers. All the safety measures a car has for example seat belts and airbags as well as the speed of the car. They must write a report on their findings and calculations as well as their solutions to the problem. In this way the learners are able to use evidence in relation to theory justification, use scientific methods to solve, explain and predict (Matthews, 1992). This method of teaching can help learners with misconceptions especially in mechanics. This method can be time consuming and not practical to apply to every concept in science, but sometimes analogies and models can be used to help learners understand abstract concepts easily. By observation learners' who are visual learners tend to excel as they are able to relate to the concept better. Learning the law or definition does not accomplish any learning and no understanding. A learner needs to observe and experiment to satisfy need for knowledge. The teacher needs to give the learner a chance to experience the truth of the theory by experimenting and guiding learners to the outcome by asking questions and stimulating the learner.

Science is not just about an ideal world, or an abstract world or mathematical calculations but it also is about the real world. History and philosophy can make the idealizations of science more human, understandable, and explain them as artifacts as their own right to be appreciated", (Matthews, 1992). By using different approaches one is able to make learners like scientists and also to make learners' aware that there is more to science than just the classroom. It's not just about a textbook and calculations and listening to the teacher or lecturer, but that it is about them, their thoughts, ideas and discussions about a concept and how well they understand it.

2.4 Views on practical work and factors that inhibit practical work

Several researchers view the purpose of practical work differently. According to Tamir (1989), practical work develops positive attitudes towards science. This suggests that practical work is used to help off-set the image of science as 'difficult', 'dull' and 'boring' (Abrahams, 2009). On the other hand, Abraham and Millar (2008) looked at the domains of knowledge and ideas, and argued that practical work is effective in helping learners to remember ideas built behind the phenomenon and the practical aspects of experiments. Practical work reposes the hidden agendas that each practical has in order to get learners to think differently and 'out of the box'. It is all about getting learners' to move from abstract level of science to a more concrete level where learners are able to see, do and apply (Hodson, 1990). We need to make the abstract thought a mere reality and allow learners to think out of the box and explore the unimaginable. But, how can we do this when we limit ourselves and our teaching to just textbook definitions and problem solving.

According to Ogunmade (2005) "quality teaching is a backbone of any educational system for developing scientifically literate citizens"p34. Ogunmade (2005) further explains that if teachers have the correct knowledge and skills there is no curriculum that can hinder their teaching abilities. He further goes on to say that with skilled, talented and dedicated professional teachers there is no reason for learners not to achieve high levels of performance. Learners are influenced on how they are taught as it isn't the subject that you remember when you leave school but rather the teacher that taught it to you. This involves a teacher's pedagogical content knowledge (PCK) which plays a vital role not just in teaching but the whole atmosphere of the class. PCK is a concept that was introduced by Shulman (1986) by arguing that it is one of the teacher knowledge domains that they need to have in order to teach effectively. This implies that if teachers lack the content-knowledge they will be unable to understand the practical and its aims and objectives and therefore this will result in practical work being in-effective. Laboratory work aids in social relationships in a constructive manner if planned well.

Teachers need the appropriate knowledge to carry out the investigation and they need to help their learners' by mediating them along the way to achieve the expected results. What we referring to here is clearly stipulated by Vygotsky (1978) which he refers to as the Zone of Proximal Development (ZPD). The Zone of Proximal development is defined as the "distance between the actual developmental level as determined by independent problem solving and

the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.33). It is very important for teachers to know their learners' prior knowledge which could be made easy by using the 'science notebook' method (Villanueva & Webb 2008; Nesbit et al. 2003). This approach of using a science notebook will allow teachers to see how and what learners do and think when carrying out experiments. Hodson (1998) points out that experiments and theory are tools in the thinking process involved in the quest for satisfactory and convincing explanations. We also think that in the process of learning physics experiments and theory also function. This ZPD that Vygotsky (1978) refers to guidance made by teachers and instruction plays a vital role as this will result in more learning than discovery if instructions are clear (Kirschner et al., 2006).

Despite being reminded about the importance and purposes of practical work, many teachers still resort to teaching using approaches which are more teacher-centered and prefer demonstrations. It is however understood, that teachers sometimes resort to demonstrations due to lack of equipment which is a problem in many schools (Hofstein & Lunetta, 1980) especially in South Africa. Therefore, Thair and Treagust (1999) placed emphasis on student-teacher interaction. This suggests that a teacher must stimulate students by constantly asking questions during a demonstration in order to gain maximum output from them. Tamir (1989) stresses on practical work being conducted correctly as this can mislead learners if the practical work is not done properly. Teachers need to be prepared and plan well in advance in order for practical work to be effective.

Time is one of the biggest factors that most teachers complain about practical work and the completion of syllabus (Abrahams & Millar, 2008; Langley, 2014 & Howie, 2003). Ramnarain and Fortus (2013) found that the implementation of the curriculum was affected by many factors and one major one was the overload of content which most teachers concentrate on as this is examinable. The curriculum unfortunately does not examine practical work which Tamir (1972) views as a unique mode of assessment where one monitors what the student does in the laboratory regarding the growth and development of inquiry and other laboratory skills. According to Villanueva and Webb (2008) teachers do not necessarily try experiments out of the curriculum and choose to do traditional experiments which are not confined to the South African context and this lack of interest and fun in teaching can be attributed to teacher's lack of pedagogic content knowledge.

Lave (1996) defined learning as an aspect of changing participation in a changing practice. She theorized that learning is social and collective. Learning is a part of participation in socially situated practices (Lave, 1996). Fundamentally, this means that Lave believed that learning, within and external to school, progresses through collaborative social interactions and that knowledge is socially constructed. Lave (1996) concluded that "informal" practices in which learning takes place in apprenticeship are influential and strong. Her theory of learning and development is based on the premise that learning is a part of changing participation in changing "communities of practice" (Lave and Wenger, 1991). Schooling communities do what they do in order to complete a curriculum and allow learners to have sufficient knowledge to enter the outside world. So, practical work makes communication skills possible and learners are able to form learning communities of practice which do not only focus on learning science but extents to improving social skills.

Another factor mentioned is the lack of resources. Laboratory environments do not confine a teacher to a classroom. Practical work involves going out and interacting with the environment to stimulate learners' and also create a positive working environment. Baird (1990) who observed that the laboratory learning environment illustrates a radical shift from teacher-centered to learner-centered by directing learning to purposeful inquiry (Hofstein & Lunetta, 2003). However, Gunstone and Champagne (1990) argue that in order for meaningful learning to take place in a laboratory one has to be given sufficient time and opportunities for interaction and reflection. This, unfortunately is something that the curriculum lacks. Many arguments are raised against laboratory work by Hofstein and Lunetta (1982) which include competency of teachers to use the laboratory effectively, too much emphasis on laboratory work can lead to little science being learned, many of the experiments are trivial and often experiments done are unrelated to the interest of the learners. It is not always about having expensive resources, but merely having a teacher that can use daily things to conduct an experiment that will have the same effect.

Different levels of conceptualization are part of teaching and learning in science. Learners' must be able to relate different quantities to each other and they need to look for relationships between variables. But how can this be achieved if a learner does not even know what the apparatus looks like or how to conduct the experiment. We are faced with such challenges in our first year when students enroll with no knowledge or limited knowledge of science and are now expected to conduct experiments following a method but have no idea what apparatus to use. Kruglak (1958) suggested that it is impossible to measure certain neuro-

muscular laboratory skills by means of paper-and-pencil tests. A student might get a perfect score on written tests but not be able to handle apparatus (Hofstein & Lunetta, 1982).

Hofstein and Lunetta, (1982); Thair and Treagust, (1999); Hodson, (1990); Bennett, (2003), Abraham and Millar, (2008) are some researchers that view practical work in a negative way as they "suggest that much of what takes place in school laboratories is of little educational value, ill-conceived, unproductive and not serving its purpose in science classrooms. For many children, what goes on in the laboratory contributes little to their learning of science". A very important concept was mentioned by Thair and Treagust (1999) that the general cookbook recipe approach to the completion of practical activities may account for low student achievement in the area of identifying and defining variables. Also, Gyoung and Mijung (2010) found that discipline was one of the problems pre-service teachers were faced with regarding safety precautions and "questioned whether or not it would be still worthwhile doing practical work in spite of the burden of taking responsibility for possible accidents". Unfortunately the current situation in South African classrooms is the fact that classes have 40 learners or more and this can pose a problem when doing practical work with dangerous chemicals and equipment. However, Gyoung and Mijung (2010) were also faced with the problem of having almost 40 learners in a classroom and pre-service teachers did not find it an easy task and felt they would rather not do practical work but were pressured between the interest of the learners and the control issues.

Practical work is said to be theory in practice, however, Abrahams and Saglam (2010) disagree as they found that "in all science subjects, there was plenty of practical work being done but it was not well integrated with the theory and it was unlikely to achieve the unique educational value often claimed [by theorists] for it". Abrahams (2009) argues that the number of pupils choosing 'A' levels decrease in physics and chemistry. This seems to be a trend as learners tend to choose other subjects rather than doing science. At university the number of physical science students is also affected as not many tend to choose physics and chemistry as their majors.

2.5 Language and practical work

Language is not just a subject but part of life as a science teacher and a person. For most learners having to receive their schooling in a different language than the one they were raised in presents a series of challenges. In recent years the socially orientated theories of

Vygotsky and that of situated cognition have had a growing influence on research in the area of language and learning (Rollnick, 2000). Vygotsky sees language as the mediator of thought. How can a student comfortably engage in the steps involved in solving problems and doing any task, if the language is not one in which they can express themselves fully. During their time at school, learners have to express themselves constantly through writing and/or speech. This becomes a daunting task for someone using their second or third language. Gee (1997) states that without reference to a community of practice, even genres of writing have no meaning. First language speakers will find it much easier to master a genre like a laboratory report or research as they are better able to identify the appropriate register to use. Second language students should first try to make sense of the language before they can even begin to look at the genre. This means that to master writing and speech in a science classroom all students should have experience and familiarity with the activities and second language students are doubly challenged for they have to learn both the social practice of the language and its place in the new social practice they are attempting to join, in this case, science (Rollnick, 2000).

"All of what we customarily call 'knowledge' is language. Which means that the key to understanding a 'subject' is to understand its language … what we call a subject is its language. A 'discipline' is a way of knowing, and whatever is known is inseparable from the symbols (mostly words) in which the knowing is codified" (Postman & Weingartner, 1971, p. 102). This basically means that words are a function of symbols through which we order and relate whatever it is that one deals with (Postman & Weingartner, 1971). Science words are aligned to the science context and according to Postman & Weingartner (1971), if one does not know the meanings of science words they do not know science. The classroom communication needs to be more language centered to serve the learning demands (Oyoo, 2009). This nature of communication and interaction enables both the teacher and the learners to have a shared meaning of all science words. The teacher's proficiency in the instructional language needs to be appropriate to the learning demands. Learner's proficiency in any instructional language is a necessary first step for all learning. Therefore, language in teaching practical needs to be a priority to enable proper acquisition of concepts.

When teaching science in school, we sometimes use different words like velocity, period, amplitude etc. that allows learners to no longer just use speed and time and height but it teaches them to use terminology that can be incorporated into their everyday lives however everyday language is not always scientific and precise. It gives them a wider range of

vocabulary that helps them to think about things differently therefore changing how people talk changes how they think (Boroditsky, 2011). Language makes it easier or harder for us to learn new things which mean that one has to understand and make sense of what they learning in their first language. Scientific language, with its own unique lexicon, grammar and semantics, has evolved from everyday language to meet the needs of the scientific discipline (Seah et al., 2014). Explanations are important as this dialogue facilitates the teaching and learning scientific explanation and also contribute to discussions on what scientific literacy is. Classroom language has two components that consist of technical and non-technical terms in the science context. The technical words or terminologies are specific to the science subject, and these may be referred to as science terms. The non-technical terms is the medium of classroom instruction or interaction from the technical terms. Moreover scientific explanations of macroscopic phenomena are taught using three levels of representation which is macro, submicro and symbolic levels (Mokiwa & Msila, 2013). These technical and non-technical can hinder the development of practical skills in a classroom. Teachers need to communicate carefully with learners to maximize learning and to make practical work worth doing.

Grammar is important in each language and this grammar plays an important role in the vocabulary used. The focus in science language was on a Lexico-grammatical level which looks at vocabulary and grammar combined. It is argued by Halliday & Martin (1993) that lexicon-grammatical features typical in scientific language are functional in constructing scientific understanding and can thus not be replaced by everyday language. By taking the importance of language into consideration increases focus on the discourse and communication and the linguistic perspective on students' explanation becomes interesting. The formation of these kinds of explanations in the learning could be regarded as part of fundamental notion of scientific literacy. And from the linguistic perspective, explaining events scientifically is regarded as a more advance language domain. Another form of language in science is the use of science diagrams which is also a form of learning aids. This form of diagrams is a form of visual literacy which makes meaning in the form of an image (Preston, 2015). Preston (2015) claims that one is not fully scientifically literate unless he or she is competent in using science diagrams and representing what they have been doing in practical diagrammatically. Which then brings us to practical work stated by Ferreira (2011) who suggests that getting learners to do practical work will allow learners' to discuss and

share ideas and it will develop their language skills, but this can only happen if learners' and the teacher revise to read proficient in the same language.

Hogstrom (2010) argues that lab work has the potential to assist students learn scientific concepts, draw students attention and motivation to learn scientific inquiry as well as give students a chance to learn practical skills and enhance their problem solving abilities. During practical work teacher-learner interactions are important. This talk and action helps learners make decisions and be able to conduct laboratory work easier and with more confidence (Hogstrom et al., 2010). Language is constantly being used in a science classroom regardless of what language it is. With common language proficiency, communication of science concepts is possible. However these science concepts are sometimes code-switched when teachers feel that a concept is not being understood especially when there a barrier in language proficiency between the teacher and the learner in the language of instruction. Furthermore, problem solving generally requires a series of steps, including the analysis of the problem, generating possible solutions, testing solutions and modifying the behaviour, or switching strategies when a solution is unsuccessful,(Baldo, Dronkers, Wilkens, Ludy, Raskin, & Kim, 2004). These steps are all part of the thought processes that will lead us to a solution and in order to solve problems effectively, we have to develop the correct thought processes.

When considering all the points above we have to agree that successful learning can only take place when a student has mastered writing and speech in the language of instruction. Teachers using methods of scaffolding and code switching during their teaching will find that it helps students to cope with speech and writing in their own but especially in a second or third language. It is a pre-requisite for understanding teacher practices and their ability or inability to scaffold learners' understanding with language awareness. Teachers also have to be made aware of these findings as they are the ones in power to change these practices and be able to make a change in terms of conceptual development. What I realized is that all what we call teaching and learning strategies including practical work are underpinned by language because they cannot be used without communication. Communication all takes place through language and it should be treated with care as it can either break or build a learner's mind when used without conscious and with awareness respectively (Haug & Odegarrd (2014). English being the language of power and being dominant in South Africa as claimed by Probyn (2005) is still not a language that seems to be used by all. Reason for this is I believe code-switching as learners' could depend on this and be lazy to actually try and understand in

English. It's also the teacher's duty to better their own language skills in order to make a success out of their subject and their learners'.

It is important for learners' to understand science as a language and science language as it is our duty as a teacher to help learners understand this language in both contexts and use it not only in a scientific community but also in their everyday lives. More importantly it is important to scaffold practical work with language awareness in order to maximize learning.

Please re-structure your arguments so that you reduce repeating the same ideas again and again.

2.6 Theoretical perspectives: Inquiry-based learning

According to Hodson (1990), most teachers did practical work but did not implement it with an inquiring perspective. Practical work is a part of all subjects but just plays a more vital role in science as this concept has gained the interest of many researchers' and has since evolved. Teachers unfortunately did not use practical work effectively as they were unaware of how to use it as a teaching and learning tool in the classroom. Stoffels, (2005); Abrahams & Millar, (2008) reveal to this day that teachers' still do not know the main purpose of practical work. South African schools unfortunately face many problems and one of them is textbooks that not all learners have. Some schools have textbooks but might lack in outlining the aims of the practical exercise and how the practical could relate to learners everyday lives (Muwanga-Zake, (1998). Muwanga-Zake (1998) argues that these practicals that are done in classrooms do not challenge learners to think intellectually.

Inquiry-based learning is the theory which guided my study. What is inquiry based learning and how does this play a role in the BEd 4th year course and in school? Inquiry-based learning is based on the recognition that science is essentially a question-driven, open ended process and that students must have personal experience with scientific inquiry to understand this fundamental aspect of science (Edelson et al., 1999). Inquiry experiences are said to improve a students' understanding of science content and practices (Edelson et al., 1999). Inquiry based learning can provide students with 3 interrelated learning objectives, (1) the development of general inquiry abilities, (2) the acquisition of specific investigation skills and (3) the understanding of science concepts and principles (Edelson et al., 1999).

General inquiry abilities involve the pursuit of open-ended questions which can be driven by learners with the help of teachers. It includes posing and refining research questions, planning and managing an investigation, and analyzing and communicating results (Edelson et al., 1999). These abilities could be a challenge in relation to the acquisition of practical or investigation skills. The acquisition of specific investigation skills refers to students being engaged in the scientific practices. The scientific world is not just a world of theory but rather some students perform better in acquiring skills. By being engaged in these practices one is allowing theory to be explained and understood differently as well as enjoying skilled work that will always be remembered rather than theory that can be forgotten.

Last is the understanding of science concepts. Here inquiry contributes to science content understanding mentioned by Edelson et al. (1999), (1) Problematize: Inquiry activities can lead learners to confront the boundaries of their knowledge or recognize gaps in that knowledge, (2) Demand: Successfully completing a scientific investigation requires science content knowledge, (3) Discover and refine: By providing learners with the opportunity to pursue answers to questions and (4) Apply: Inquiry activities can give learners the opportunity to apply their scientific understanding in the pursuit of research questions. Although inquiry experiences can provide valuable opportunities there are also challenges that make it difficult to implement. Edelson et al. (1999) mentions five challenges, (1) Motivation, (2) Accessibility of investigation techniques, (3) Background knowledge, (4) Management of extended activities and (5) The practical constraints of the learning context. Motivation can be viewed in many ways regarding what context it is looked at. Some teachers might use it to gain the learners' interest and others might use it to achieve learning and understanding of concepts. Bandura (1986) looks at motivation as an 'inner drive of action'. Meaning that learners will be actively involved in science clubs, doing more than what is expected in class (over achievers), reading science books/magazines, watching programs, visiting places etc. (Abrahams, 2009). If this 'inner drive of action' fails to be present in the lesson it could negatively impact learning and learners' will fail to participate in inquiry activities (Edelson et al., 1999).

Prenzel suggests that the term 'interest', as, commonly used, describes preferences for objects (Abrahams, 2009). Here the term interest refers to the personal interest of the learner. Renniger (1998) and Schiefele (1996) found that children who have an interest in an activity or a subject will excel and want to learn more as well as pay closer attention to detail. They will also spend more time in trying to figure things out or how it works as it captures their

attention and challenges them cognitively (Abrahams, 2009). Many researchers such as Alexander (1997), Alexander, Jetton & Kulikowich (1995) and Deci (1992) in Abrahams (2009) believe that by increasing their knowledge of that subject or activity they increase their personal interest and further develop what might usefully be thought of as a system of positive feedback. Motivation and interest in practical work is a way of attempting to make students fully aware as well as understand the ways scientists work, and also equipping and preparing students for their possible careers in science and technology (Akinbobola & Afolabi, 2010).

This then leads to learners' participating in authentic activities which provides them with the motivation to acquire new knowledge and add to their existing knowledge and it gives them an opportunity to apply this knowledge (Edelson et al., 1999). Authentic tasks are tasks that give learners the opportunity to experiment amongst themselves with a facilitator to guide them but also, it sometimes involves a different environment that helps them to enjoy an everyday experience in a real life setting. Authentic tasks give learner's the opportunity to engage in real life activities that might help them choose their career path and subject choices. This can help learners reason and interact with the people around them to solve problems and to look at things differently. Learners are able to see the complexity of problems people encounter in their daily jobs and how they can resolve these problems and what precautions and debates are taken before a solution is given. The only time tasks will seem difficult is when a teacher's content knowledge is poor.

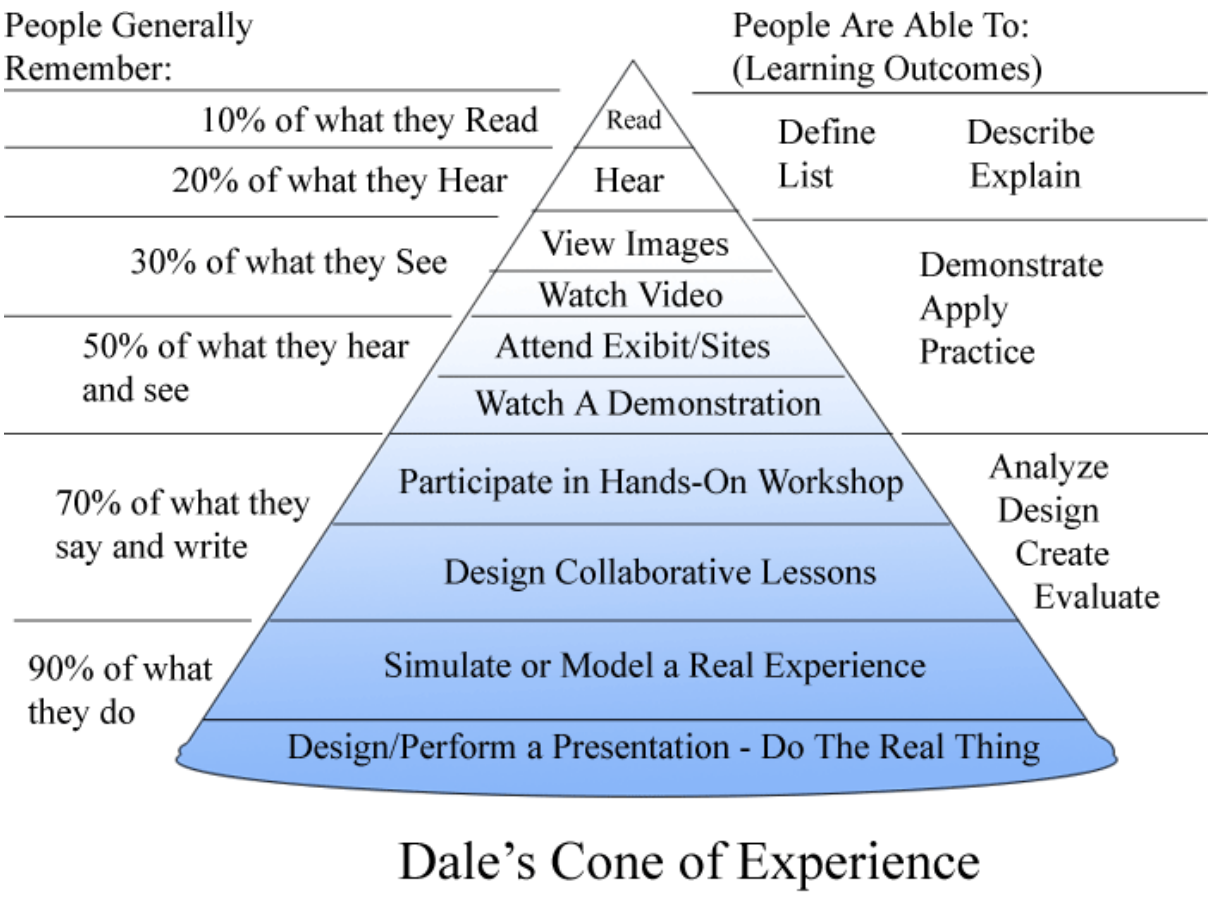


Figure 2.1: Dale's cone of experience (Dale, E. 1954)

Dale's cone of experience is explained as "a pictorial device used to explain interrelationships of the various types of audio-visual media, as well as their individual positions in the learning process (Dale, 1954). The cone is a way of explaining how to utilize instructional resources and activities. The cone reflects relationships that are based on educational experiences that is real life scenarios and everyday life scenarios. By utilizing the cone of experience one gives learners the opportunity to use a variety of their senses like sight, smell, hearing, touching and movement (Dale, 1954). In order to experience something one has to use all senses and by using all senses one is able to interact with resources in a more active manner as well as allowing learners to learn from it more easily. The cone basically wants to move a learner from the concrete to abstract. Edgar Dale's research from the 1940s suggests that the best method of active learning in a classroom is at the bottom of the cone and consists of fieldwork, hands-on activities or situated learning that was mentioned earlier. Dale straight forwardly says "do the real thing", don't read about it, or listen to someone else describe it. Be the one to experience and talk about it. The cone functions in an upside down manner where the top is less important or the methods used are

least effective. This section of the cone consists of reading, listening or doing presentations which can be ultimately boring and non-stimulating.

The cone of learning also underlines the premise that if you show someone how to do something, they will probably remember. But if you involve them in a meaningful way, they'll likely understand it better. In other words, the most durable form of learning is when you involve the learner directly in a meaningful way and preferably through the availability of hands-on experience. This cone of experience is an excellent way of helping teachers to plan their classroom activities and practical in a way that assists learning to take place in a very easy and stimulating environment.

2.7 Conclusion

This chapter was designed to review literature around practical work. I started by presenting the aims and objectives of the South African curriculum and linking them to practical work. On this matter, I have argued that although the aims are very clear, they are not met by the teachers. Science curriculum requires teachers to teach practical work but they do not due to factors like time and lack of resources. I then presented literature on the history and philosophy of science and discussed that practical work is central to this notion as it reflects what scientists actually do to develop science knowledge. I looked at views around practical work. Literature shows that practical work can enhance understanding only if it is effectively facilitated by teachers who are well-trained. I presented perspectives on language and stated that language can hinder acquisition of concepts in practical work. Teachers need to use the correct science terms in the correct context. I finally presented ideas on inquiry based learning and argued that practical work is part of inquiry based learning. This then allows one to look at research design and methodology which serves to justify and validate this research.

Chapter 3: Research design and Methodology

3.1 Introduction

Every lecturer, pre-service teacher and teacher do things differently but can achieve the same outcomes. Pre-service teachers are privileged in many ways with regards to equipment and the environment they study in. Whereas in schools they are challenged with many aspects regarding practical work. This research is to help pre-service teachers as well as practicing teachers to gain insight to part of the problem which involves preparing our students for the reality of school life.

This chapter best describes the research methods used to investigate the B.Ed Science 4th year and how it prepares pre-service teachers to teach practical work in schools during teaching experience. This research is focused on four research questions that were the basis of this study. The research questions:

1. What is it that lecturers say about the objectives of the Physical Sciences IV course?
2. What practical activities are carried out by pre-service teachers? What is the importance of these practical activities according to the pre-service teachers?
3. What are the perceptions of B.Ed 4th year Physical Science teachers with regards to practical activities during their teaching experience?
4. How are practical skills transferred from B.Ed to a school context?

This study was structured according to Abrahams and Millar model (2008) shown in figure 3.1 that was modified for the benefit of this specific study.

Morrell and Carroll (2010) argue that educational researchers need to think about the research methods that they will use in their studies. Research methods are basically the ways in which data is collected and analyzed (Opie, 2004). However, these methods have to be aligned with the research questions and they are determined by the research paradigm. This chapter deals with the research design and methods. I start by presenting how I selected the participants. I then discuss how the data was collected and the instruments used to collect the data. I then look at data analysis and interpretations and look at ethical considerations. I finally present how validity and reliability was ensured in this study.

3.2 Sampling and Participants

The researcher chooses participants based on the objectives of the study and based on certain factors of the participants (Opie, 2014). This study involved twenty seven B.Ed 4th year Physical Science student teachers. Six of these student teachers were followed during their teaching practice. The six that were followed chose their own schools for doing teaching practice. In the schools that they were in, they were given mentor teachers. Furthermore, three lecturers who are involved in the teaching of these 4th year B.Ed students were interviewed to understand their perceptions of practical work and their reasoning for inclusion of practical work in the B.Ed. The lecturers were chosen because they were teaching the Physical Sciences IV course to 4th year students.

3.3 Data collection and instruments

The purpose for collecting data was related to the practical work done in the B.Ed course and the actual practical work carried out at schools.

A Qualitative approach was used in this study. Qualitative methods according to Berg (1989) allows one to partake in different surroundings with different social interactions which helps researchers to understand, perceive and explore what people do in their daily activities. Berg (1989) does not only emphasize on using qualitative methods but also explains the importance of quantitative methods that are more complex but easily attainable. However qualitative methods of collecting data can be overwhelming as large amounts of data is collected and not all the data is relevant to the study. Only after analyzing that data will one be able to sift what is needed or not. In this way one is able to collect a vast amount of data differently which can enhance what one is looking for in different ways. This increases the trustworthiness and reliability of the results and also opens doors for other research.

Data was collected through video-tape recordings, questionnaires, interviews and student teachers' laboratory reports. To answer my research questions, I needed to conduct semi-structured interviews with the lecturers, mentor teachers and student teachers. All video-recordings and interviews were transcribed.

All questionnaires were modeled using TIMSS (1998) and adapted to fit the research questions. The information was used to make decisions about sampling and about which

curriculum guides and textbooks would be appropriate to the analysis. It was also used to identify issues that would need further clarification from the other instruments.

The lecturer's survey comprised of seven questions to elicit the objectives, criteria and skills of practical work. Lecturers were also asked the relevance of this practical work and how it is linked to prepare pre-service teachers in schools.

The teachers were interviewed as this assisted to identify how the curriculum practical work was delivered, assessed and taught as well as limiting factors of quality that could be barriers for pre-service teachers.

Pre-service teachers were interviewed and surveyed with a questionnaire to gain insight into their perceptions of practical work in the B.Ed 4th year course and their competence and work attitude during teaching experience.

Opie (2004) outlines that in order to elicit one's ideas and opinions, we need to conduct interviews. I used interviews to elicit lecturers' concepts about the objectives and aims of the PS IV course. These objectives were listed in the course outline given to students and I interviewed the lecturers in order to understand their thinking behind these objectives and why they are teaching practical work to 4th year B.Ed students. I also looked at the practical manuals and worksheets in order to see the extent to which the practical work enabled pre-service teachers to prepare themselves. Since I am looking at practical work and how it is done in schools by student teachers the video-taping allowed me to deeply look at what is actually happening in the classroom as Lichtman (2006) argues that observation forms the basis of a qualitative study.

Through this triangulation of collecting data from lecturers, pre-service teachers and teachers, this research is able to provide more motivation as well as more efficient and confident classroom teachers with regards to practical work.

3.4 Data analysis and interpretation

In analyzing the lessons observations transcript, I used Abrahams and Millar (2008) model on the process of design and evaluation of practical work as well as Tiberghien (2000) practical work linking two domains. I marked the laboratory reports based on what students had produced.

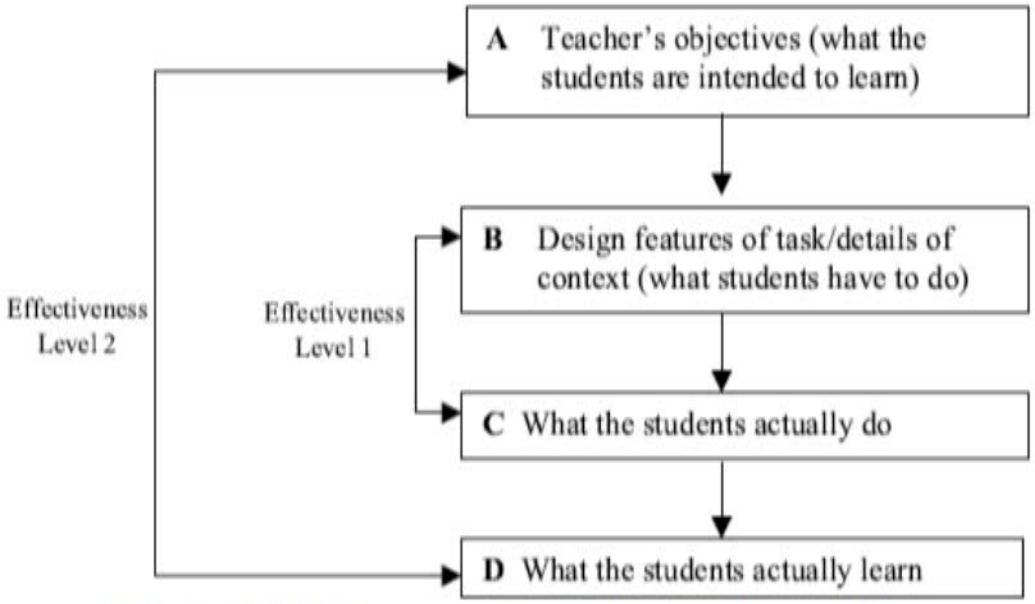


Figure 1. Model of the process of design and evaluation of a practical task

Figure 3.1: Model of the process of design and evaluation of practical work (Abrahams & Millar, 2008)

For this particular study the framework is modified slightly to fit the purpose of the study. Figure 3.2 below illustrates the modified model of the analytical framework:

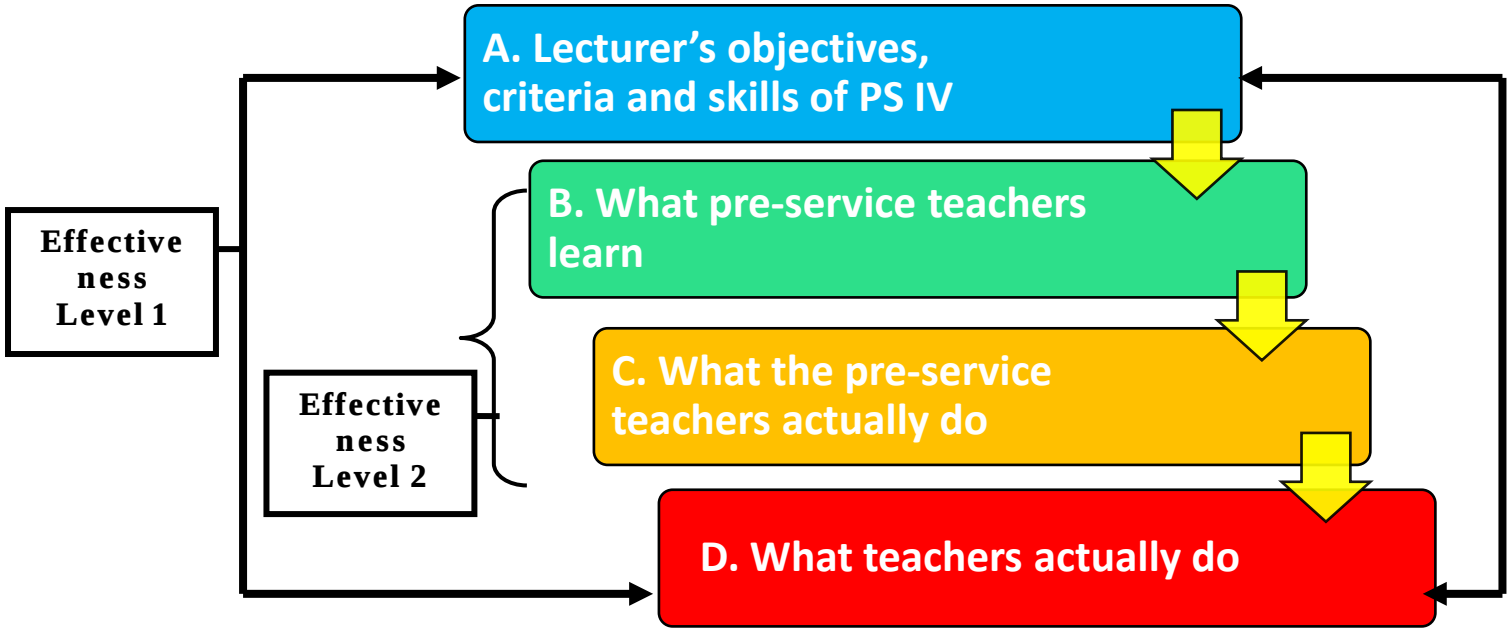


Figure 3.2: Modified model of design and evaluation of practical work

This model enabled the researcher to be able to consider and evaluate the matches between what the lecturer intended pre-service teachers to do and what pre-service teachers actually do; this will result in the effectiveness of the task at Level 2. This model further enabled me in matching what the lecturer intended the pre-service teachers to learn and what they actually learn, which will result in the effectiveness of the task at Level 1. The raw data of the research project will be analyzed using the analytical framework by Abraham and Millar (2008). Basically I will be using this model to evaluate the effectiveness of the practical tasks that the pre-service teachers will be doing.

3.5 Ethical Considerations

Opie (2004) says that educational research which involves human beings has to be conducted in an ethical manner. Ethical considerations include being able to give your participants assurance that they will remain anonymous at all times during the research and after.

For ethical considerations, one has to seek permission from the University which is done by filling in an ethics application that will be reviewed and only once an answer and protocol number is given can the research take place. All participants were given information letters as well as consent forms as this was to allow the participant to read what the research is about and that they can decide not to participate whenever they choose to. These forms also assure anonymity and confidentiality with regards to the study and it is voluntary. Ethics clearance was sought from the Wits School of Education.

3.6 Research Rigour

Research rigour has to do with the validity and reliability of the study. According to Opie (2004) validity is about the extent to which the research tools measure what they are supposed to measure while reliability has to do with reproducibility of the results if the study was conducted again using the same instruments under same conditions.. In this study, validity would refer to the accurate portrayal of the findings about pre-service teachers' use of practical work and their perceptions. To address the issue of validity and reliability, the students' scripts will be used together with the observation transcripts to see if there are any gaps with regards to applying theory and writing it up in a laboratory report. In developing the questions for the interviews, I looked at the what, why and how of each institution and developed questions that were close to the literature read. Pre-service teachers were probed

based on the answers that they provided and the researcher remained impartial when analyzing the interview transcripts. Lecturers' interviews were validate by going on to look at the practical work given to students and code them according to the five practical skills needed. The video-recorded and interview transcripts were transcribed by me and checked a few times for reliability and validity and isolating emerging themes from that.

3.7 Conclusion

The main aim of this chapter was to present the research design and methodology. These refer to how the research was conducted and how the data was collected and analyzed. I started by presenting how I chose my participants. The participants were students and their lecturers who are doing science. I then explained how the data was collected and instruments used to collect the data. I then described the model of evaluating practical work as my data analysis model. I then presented ethical issues related to this study. Lastly, I looked at how validity and reliability was ensured in this study.

Chapter 4: Data Analysis and Discussion of Results

4.1 Introduction

This chapter involves seeking of answers to the research questions posed in chapter 1. Each of these questions will be discussed in detail. At the end of this chapter a complete summary of the findings will be given as well as an integration of the lecturers, teachers and student-teachers perspectives will be all looked at holistically. This will be looked at this way as this is a cycle that begins with the lecturer, the student-teacher and then finally the teacher. It would have been interesting to actually follow one student-teacher throughout their physical science degree to witness the complete change of a student to a teacher and how practical work develops and changes with time and experience. Unfortunately time constraints limits us as well as the change in lecturers and their objectives of each course during each year. The research was aimed at answering these questions:

1. What is it that lecturers say about the objectives of the Physical Sciences IV course?
2. What practical activities are carried out by pre-service teachers? What is the importance of these practical activities according to the pre-service teachers?
3. What are the perceptions of B.Ed 4th year Physical Science teachers with regards to practical activities during their teaching experience?
4. How are practical skills transferred from B.Ed to a school context?

There are three stages of results presented in this study of which the first stage involved the lecturers and the objectives, criteria and skills involved in practical work for the PS IV course. The second stage involved the student-teachers perspectives, views and opinions as well as skills involved in doing practical work at university and during teaching experience. The third stage involved teachers' views and perspectives on practical work. The analysis of each then follows.

4.2 What is it that lecturers say about the objectives of the Physical Sciences IV course?

This section deals with results and discussion from what the lecturers said about the B.Ed 4th course. After interviewing two lecturers that are the foundation of this course I found it refreshing to know that both had the same objectives in mind.

From the table 4.1 (Annexure 2), it is clear that both lecturers felt strongly that theory must link to the practical work and this statement was mentioned three times by lecturer B to state its importance and pre-service teachers must gain confidence to do practical work in a classroom. The criteria chosen for this course is simple as the theory done in the course must have practical work to validate it as well as use and familiarize themselves with the apparatus and to work with what is available. Three main skills were mentioned with regards to the PS IV course that is (1) Content competency, (2) Mathematical modeling and cognitive manipulation skills and (3) Practical and safe handling of equipment skills. This practical work are included in the PS IV course "To show that physical science is a practical subject where theory and practice should be gained simultaneously" (Lecturer B).

Lecturers also commented on the relevance of the practical work: They are relevant with regards to "*reinforce theory content taught in the lecture and to give students opportunities to link this theory with practical observation. This is especially important as it enables the students to then ponder more on what they have learnt*" (Lecturer A).

Table 4.2: Analysis of practical worksheets given to students

Practical No.	Motivation	Linking theory with practical work	Development of manipulative skills	Nature of science development
Practical 1	√			√
Practical 1.1		√	√	
Practical 2	√			√
Practical 2.1		√	√	
Practical 3	√			√
Practical 3.1		√	√	
Practical 3.2		√	√	
Practical 4	√			√
Practical 4.1		√	√	
Practical 5	√		√	√
Practical 5.1		√	√	
Practical 5.2		√	√	
Practical 6.1		√	√	√
Practical 6.2				
Practical 7	√			√
Practical 7.1		√	√	
Practical 7.2		√	√	

Table 4.2 shows the results for analysis of practical worksheets (manuals) given to students. All the practical work categorized according to four purposes, (1) Motivation, (2) Linking theory with practice, (3) Development of manipulation skills and (4) Nature of science development. This is a way of comparing the actual lecturer's utterances and what they planned for pre-service teachers to do. The design of these practical activities plays a vital role in what takes place with the student teachers and the theory they have learnt.

When lecturers were asked about the way in which they design the practical work and their reasons for choosing certain practical activities, they said that these practical activities are designed per topic on a central concept that is filtered by many resources and put together to gain the best understanding. These practical's are not designed to fit the CAPS documents as the "*aim of the course is not to train teachers solely for the SA Matric system. We also want our teachers to be competent practitioners in the IEB and the A-level systems as well." "I believe that if teachers find themselves teaching these topics in the CAPS curriculum, they can then design and use the same practical's that they learned during training*" (Lecturer A).

From the seven practical's 6 out of 7 had a motivation start before the actual practical that required a lot of observation and it was practical experiments that revolved around daily life experiences which is linked to the nature of science. The actual practical work are all theory linked aid in the development of practical skills like manipulation and handling of apparatus. Although lecturers' did not comment on the motivation part of practical work, the practical work prepared showed it. It can be argued that all the practical work given helped pre-service teachers develop manipulative skills. The practical work also showed nature of science development and linked theory to practice which is what was emphasized by lecturers – that practical work should link theory to practice. This is desired as it enhances learner understanding of science content (Ching, 2014). Furthermore, they motivate learners. Motivation practical work is seen as an "inner drive to action" (Abrahams, 2009).

The typology of the lecturer's ideas and views of practical work is seen as the basis for student-teachers and teachers conducting practical work as this is seen as a series of what the lecturer said "See and remember and Do and understand". Bennet (2003) indicated that there should be a relationship between the nature and type of practical work is involved in a study and assist in this context to analyze the lecturer's ideas of practical work from that of student-teachers and teachers. Both lecturers' views seem to be extremely focused but this focus in mind is not always clear and does not function hand in hand with the CAPS documents and

pressures of what is actually expected of a science teacher, how they are trained as well as department and curriculum pressures. The content here plays an important role in pre-service teachers careers however the pressures of reality in a school does not allow them to practice what is taught due to constraints mentioned such as time, equipment, language, etc. (Thair & Treagust, 1999). Although lecturers expressed the importance of practical work to pre-service teachers, Osborne (1993) thinks that practical work is less important to students' learning of science.

4.3 What practical activities are carried out by pre-service teachers? What is the importance of these practical activities according to the pre-service teachers?

Seven practical activities were carried out by the student teachers during their specified course in Physics fourth year (Annexure 4). In order to measure pre-service teachers' skills that they get from the course, I analyzed their laboratory report exam scripts. The main aim of analyzing these scripts was to get a sense of what they produce after being involved in practical work and to look at what they actually learn through doing practical work. I analyzed all the 27 scripts. This exam was focused on a specific concept using a pendulum.

The table below shows what the scripts showed. A script was coded under the conditions that it had representations and deductions. For example if a certain script showed calculations, variables, units and diagrams which aligned with the design, it means that practical work skills were evident in that particular pre-service teacher's report.

Table 4.3: Pre-service teachers' scripts coding

Script no.	**Description**	**Design**	**Representation** Diagram (D); Graphs (G)Correct (Cor)/Incorrect (IC) variables(V); Tables (T); Calculations (CAL); Units (U) (Cor)/ **(IC)**	**Deductions** Conclusion (C); Error analysis (EA**)**
1.	√	√	D, G(ICV), T, CAL, U(Cor)	C , EA
2.	√	√	D, G(ICV), T, CAL, U(IC)	C, EA
3.	√	√	D, G(ICV), T, CAL, U(Cor)	C

4.	√	√	D,G(ICV), T, CAL, U(IC)	C, EA
5.	√	√	D, G(ICV), T, CAL, U(IC)	C, EA
6.	√	√	D, G(ICV), T, CAL,U(Cor)	C, EA
7.	√	√	D, G(ICV), T, CAL, U(Cor)	C
8.	√	√	D, G(ICV), T, CAL, U(IC)	C, EA
9.	√	√	D, G(ICV), T, CAL, U(Cor)	EA
10.	X	x	D, G(ICV), T, U(Cor)	C,
11.	√	√	D, G(ICV), T, CAL, U(Cor)	C, EA
12.	√	√	D, G(ICV), T, CAL, U(Cor)	C, EA
13.	√	√	D, G(ICV), T, CAL, U(IC)	C, EA
14.	√	√	D, G(ICV), T, CAL, U(IC)	C, EA
15.	√	√	D, G(ICV), T, CAL, U(Cor)	C, EA
16.	√	√	D, T, CAL, U(Cor)	C
17.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
18.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
19.	√	√	D, G(Cor), T, CAL, U(IC)	C, EA
20.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
21.	√	√	D, G(Cor), T, CAL, U(Cor)	C
22.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
23.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
24.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
25.	√	√	D, G(Cor), T, CAL, U(Cor)	C, EA
26.	√	√	D, G(Cor), T, CAL, U(Cor)	C
27.	√	√	D, G(Cor), T, CAL, U(Cor)	C

In order to understand pre-service teachers' conceptions about practical work, I used questionnaires. The questionnaires consisted of open-ended questions in order to give them

an opportunity to fully express their views and conceptions. In this section, I present the analysis, results and discussions from the questionnaires.

Table 4.3 reveals a lot of what the pre-service teachers have learned and mastered in there 4 years of experience in the laboratory. Firstly the description and the design was done well by 26 students whereas only 1 pre-service (PST10) teacher came unprepared. However this pre-service teacher should have had an idea of what to do as they were told to prepare in advance. With the 4 years of experience one should be able to improvise and link the theory done to the practical given.

All 27 pre-service teachers included diagrams which show good practice of skills introduced to them in their first year. 15 pre-service teachers included graphs but their graphs were incorrect due to incorrect variables. This can be a major misconception and can become problematic if students in 4th year cannot recognize dependent and independent variables (Annexure 5). This concept was mentioned earlier in the research by Thair and Treagust (1999) that if students are following ‘cookbook ’recipes “it may account for low student achievement in the area of identifying and defining variables”. Does this mean that in schools they depend more on a memo set by departments and therefore are able to complete graphs easily? One pre-service teacher had no graph at all. This could imply that this pre-service teacher was unable to or did not have a clue as to what was being investigated and neither attempted to draw a graph. Another student drew a graph but was unable to analyze the graph. This could imply that the student was unsure about the graph and the relationship being investigated.

Eleven pre-service teachers were competent enough to draw graphs with correct variables. This is less than half the class which needs attention. All 27 students neatly organized there results in tables. However the tables did not always have the correct units included. Seven pre-service teachers out of 27 used incorrect units or no units at all in their tables and calculations. Twenty-six pre-service teachers did calculations that were correct and partially correct but used correct formula with regards to being planned before they walked in. However one pre-service teacher did not do calculations. Twenty-six pre-service teachers wrote a conclusion and only 20 of them did an error analysis.

As scientists one needs to understand that there is always uncertainty in the results collected and a conclusion has to answer your hypothesis and aim. It is important to state what one has found and also give reasons as to why some results could have been incorrect. As science

teachers although we know what is expected in practical's we also know that it does not always happen that way. In this case we need to improvise and also give reasons to learners as to why a certain practical did not work. The surprise element of science is lost when one expects a certain answer. The plot of being a scientist is lost and sometimes inventions are created due to mistakes that are then explained and perfected. By giving students expected answers you are killing the surprise element which turns out to be a boring practical that students lose interest in. This is the same as doing "experiments and demonstrations verbally and all answers dictated" (Thair & Treagust 1999).

Investigating and writing a report plays a vital role in the process of scientific inquiry. The laboratory report says more than just sentences and figures. It is a formal report that is made up of a scientific method which has 6 steps to follow. The following steps are generally what is expected in a laboratory report, (1) Purpose/Question, (2) Research, (3) Hypothesis, (4) Experiment, (5) Data/Analysis and (6) Conclusion. These steps of inquiry based learning is explained by Pedaste et al., 2015 as an educational strategy where student's follow methods and practices similar to those of scientists. This way of learning emphasizes active participation and is the responsibility of the learner to discover the knowledge (Pedaste et al., 2015). It was found by Alfieri et al., 2011 that inquiry teaching resulted in better learning compared to that of traditional and unassisted learning. This six step process is an easy and ordered way of presenting new knowledge found. However Pedaste et al., 2015 does mention that inquiry based learning is not a prescribed, uniform linear process. This was mentioned above that when doing experiments things do not always go planned.

This laboratory report is an indicator of what pre-service teachers have learned in four years of experience at university. However a school context is very different and worksheets are supplied by the government to make practical work easy to follow and assess. This knowledge of writing a report is vital, meaning, that if you as a pre-service teacher knows what is expected of you, you will then instruct and mentor your learners to give you what you expect.

What pre-service teachers learn is not always connected to what they do on TE (Teaching Experience). This pressure of TE sometimes suffocates them with regards to what they plan and what the school wants and what the curriculum expects. At university they work well in the time given to them whereas in school they are rushed for time as factors such as discipline, resources and language affect their teaching time. Pre-service teachers are

equipped well for the PS IV course with regards to practical work as this is shown in the way they are able to handle apparatus and manipulative skills when doing practical's in schools. The content course empowers them with content and practical application but does not really assist them in a school situation. 3 Out of the 6 pre-service teachers followed, chose to do a demonstration rather than getting learners to do it themselves. This could be a fear of what could go wrong as a lot of pre-service teachers managed to get apparatus to allow their learners to work in groups. The initiative comes from the teacher.

This flaw in the system can be dealt with more in the methods course where we can equip pre-service teachers to deal with practical work in all situations and to also get them to use the CAPS curriculum in a school environment. I think that in 4th year methods we need to include TE for the whole year where we allow our pre-service teachers to choose a mentor teacher and assist these teachers for all practical's during the year. This will allow our pre-service teachers to be more confident during TE and also will be prepared for what is expected when they qualify. Experience grows confidence and with confidence learning is achieved.

In order to understand pre-service teachers' conceptions about practical work, I used questionnaires. The questionnaires consisted of open-ended questions in order to give them an opportunity to fully express their views and conceptions. In this section, I present the analysis, results and discussions from the questionnaires.

Table 4.3 shows a summary of what pre-service teachers said in each question. From the table, we are able to see that pre-service teachers are enthusiastic about doing practical work in the course. But there are some few things that they are not happy about. These things can hinder the way in which they will perform practical work at their respective schools.

Table 4.4: Student-Teachers questionnaire and the analysis of their responses to each question.

Questions	Responses
1. What is your opinion on practical work in the B.Ed course?	All 27 students agreed that practical work in the B.Ed. course played an important role especially when going out on teaching experience.
2. Do you design your own experiments?	24 students said yes and 3 said no.

3. What condition is the laboratory equipment in?	27 students - most apparatus is in working order. 10 students – there is not enough equipment for all students in the course.
4. Is the theory you do in class related to the practical work?	15 students- YES 12- The theory is not always related or seems more difficult when actually collecting data and calculating what is wanted.
5. Do you prefer working with peers or on your own when conducting practical work? And why?	5 students- preferred working on their own. Reason: All 5 believed that they want the experience of carrying out practical work on their own and improve their skills and confidence. 22 students- preferred working with peers. Reason1: Sometimes there isn't enough time to do a practical alone so each member contributes in order to complete in the given time. Benefit from each other. 10 students Reason2: Sometimes we don't really know what is going on and our peers help us with our reports and calculations.
6. Describe your learning environment?	18 students- Positive learning environment 7 students – Why can't we be able to use the laboratories on main campus as those laboratories are very advanced technologically.
7. What was your ideal laboratory experience?	Most students wanted to experiment fun things that most learners would be interested in, but was not part of the PS IV course or the CAPS curriculum.

All 27 pre-service teachers deemed practical's to be an important aspect of the PS IV course, especially ST2 in Table 4.5 below who stated in the interview that "practical work should be trialed then practiced with theory to gain application and experience".

Three pre-service teachers claimed they do not design experiments however this was incorrect as they did for the practical exam and had to come in prepared. This could imply that they might not know what design entails.

Twelve pre-service teachers said that the theory is not always related to the practical but later said that it is more difficult to collect data and do calculations. Here the skills of practical work play an important role and not just theory and calculations. It is about linking the theory

you are doing instead of following a recipe. It's all about coming prepared to class with the theory backing your results. Abrahams (2009) does mention that "pupils can be fully engaged and seemingly interested in what they are doing without being cognitively engaged with the task in a manner that would have been necessary for them to have learnt what the teacher intended". This is clearly shown in the laboratory reports where some of them seem to know theory but cannot use it in an actual practical with data.

Working in groups and individually I find challenging. Twenty-two pre-service teachers said they prefer working in groups whereas the other 5 preferred working individually. Time was mentioned as a factor whereas some depend on their peers to help do all the work and pass easily. To some pre-service teachers the practical part allows them to improve their overall results so that the course work mark is high enough for them to pass. This however shows a lack of interest. Abrahams (2005) argues that many students in secondary schools did not like practical work. Some of them did not like to work in groups and this is what practical work emphasizes. Group work does have its benefits as peers can learn from each other as well as improve their skills in the laboratory.

4.4 What are the perceptions of B.Ed 4th year Physical Science teachers with regards to practical activities during their teaching experience?

I followed 6 pre-service teachers to schools during the teaching practice. I wanted to see if they are able to implement the skills that they learn at the University. Generally, I wanted to look at how they conduct practical work since they would now act as teachers and not students. In this section, I present the results and discussion on how pre-service teachers conducted the practical work in their classrooms during teaching experience (TE).

Table 4.5 below shows how the video-recordings were coded according to what pre-service teachers do in their classrooms. For example, if a certain student teacher facilitated the practical in a way that there was discipline, it was coded STD. All codes are in the table below. I looked at 15 aspects of practical work shown in the first column. ST1 refers to student teacher number 1 and so on.

Table 4.5: Coded Video Recordings

How practical work was conducted	ST1	ST2	ST3	ST4	ST5	ST6	CODE
CAPS requirements	√	√	√	√	√	√	**STC**
Motivation		√			√	√	**STM**
Discipline	√	√	√	√	√	√	**STD**
Apparatus	√	√	√	√	√	√	**STA**
Individual work							**STI**
Group work		√			√	√	**STG**
Worksheet to be followed	√	√	√		√	√	**STW**
Demonstration	√		√	√			**STDe**
Illustration	√			√			**STIL**
Investigation		√			√	√	**STIV**
Observation	√	√	√	√	√	√	**STO**
Enquiry		√			√	√	**STE**
Observation and handling of apparatus		√	√		√	√	**STOA**
Theory linked to practical	√	√	√		√	√	**STTP**
Learners had the opportunity to act as scientists		√			√	√	**STS**

The table shows that all student teachers did practical work which is in line with the CAPS curriculum. For each of these practical activities, they all had apparatus and learners were able to observe. However, only 3 pre-service teachers gave learners an opportunity to act as scientists. More importantly only 3 pre-service teachers gave investigations which were inquiry-based. However, there was evidence that theory was linked to practical work and worksheets were followed after every practical.

Although all teachers incorporated practical work in their teaching, all practical work done was due to SBA tasks required for the year. 3 Out of 6 teachers motivated their learners to do practical work and allowed their learners to act as scientists. Baker (1998) found that students who had negative attitudes towards practical work did not associate themselves with scientists or see themselves going somewhere with science as a subject. The possibility is that these pre-service teachers did not see their learners as future scientists. In other words,

teaching to them was more related to finishing the syllabus than nurturing their learners to suit the image of science (Cleaves, 2005). All 6 teachers maintained good discipline and made sure there was apparatus available be it a group or demonstration practical. 3 teachers did group work, 2 did a demonstration and 1 did a demonstration with illustrations. 4 pre-service teachers allowed their learners to observe as well as handle apparatus whereas the other 2 pre-service teachers did demonstrations and learners just observed.

All 5 pre-service teachers did practicals that were theory based on what they had taught previously whereas one teacher was demonstrating and illustrating as well as teaching theory during the lesson. This can cause confusion as these learners were unfamiliar with some scientific terms as well as the apparatus being used and where it should be used. How apparatus is introduced is just as important as how the lesson is taught. The pre-service teachers that chose to do demonstrations could have been pressured with time or syllabi or were not confident enough to carry out the practical work with a class of learners. Thair & Treagust (1999) refer to actual school situations whereby teachers choose to do demonstrations due to "teachers rushing with syllabi" due to "the exam-oriented educational system which produces time constraints in terms of completing science". This is very similar to the CAPS document that most teachers try to follow and seem to prioritize content over practical work.

4.5 How are practical skills transferred from B.Ed to a school context?

The next typology was used to analyze the student-teachers practical work in the PS IV course as well as on teaching experience using Millar's model (2002). This model was based on developing and evaluating laboratory tasks and helped the researcher analyze how the student-teachers conducted their practical work during teaching experience. This typology took into consideration how student-teachers view science at university and how they use this knowledge and skills during teaching experience. This transfer of knowledge and practical skills is looked at and analyzed from table 4.1, 4.2, 4.4 and 4.6. The pre-service teachers are analyzed according to their shift from the B.Ed 4th year course to what is actually done in schools and how it was carried out.

Lecturers argued that the practical skills are transferred from the PS IV course to a school context during TE. "*The students are encouraged to be familiar with all equipment so that they can be able to perform the experiments at their schools. They learn similar skills from*

different experiments to show that it is the standard to use even at matric level. During TE some of the skills are assessed and encouraged for students to show before they finish their degrees" (Lecturer B).

What I found to be convenient in the B.Ed 4th year course is the fact that students are still given everything needed for practical work because lecturers commented that students get all the apparatus they needed and these apparatus are set before the practical. This could be seen as a disadvantage to the students and maybe the reason why they prefer doing demonstrations. According to the laboratory technician that I had interviewed. I was made aware that the B.Ed 4th year students are not capable of setting up laboratories and having to make chemicals. All apparatus and chemicals are ready before students enter laboratories. This can be linked to Millar's (2004) finding that most schools do not care about practical work. The technician saw a need to set up for pre-service teachers because they were not capable of doing that due to how they were taught at their respective high schools and how they were taught at university.

Going into the actual teaching in schools taking place we look at table 4.4 which analyzed the pre-service teachers teaching experience of practical work. Looking at the practical work that was carried out 4 pre-service teachers did a physics practical whereas the 2 teachers did a chemistry practical as followed by the mentor teacher instructions. ST1, 2, and 4 carried out an electricity practical and ST3 and 6 a chemistry practical on Boyle's Law and ST5 a practical on Light. Looking at these practicals with regards to Table 4.2 one can see a clear relationship with the B.Ed 4th year content and how in depth the content and practical work is and how this practical work is much more than what is expected in a classroom. For example Practicals 5, 6 and 7 (Annexure 4) all relate to the practical work being done in schools. Looking at the practical work ST2, 5 and 6 were not just carrying out the practical work. They were actively involved in assisting learners as well as explaining and making learners understand what they were observing and why they were observing. ST2 had a brilliant way of explaining parallel and series circuits. What ST2 did was he made his learners stand opposite each other explaining parallel and made them stand next to each other holding hands explaining series. He then asked them to link that analogy to a circuit board which allowed his learners to understand what they were doing and why wires were connected that way. This proves strong content and pedagogical skills that allowed these pre-service teachers to take control and also enjoy the practical aspect with their learners. These pre-service teachers had mentor teachers that supported them that made a very big difference in their confidence

levels. ST1, 3 and 4 were basically left on their own to set up and carry out practical work which made it challenging but not impossible for them to carry it out. ST1 had no teacher as the teacher had left the school, ST2 and ST3 were given the tasks and apparatus to carry out without the teacher as the mentor teachers had other commitments. Here is where there skills are tested for improvising and also making the effort to do practical work which illustrated their own initiative. As pre-service teachers they are not left alone and always have a supervising teacher to assist and guide them on how to carry out a lesson or carry out practical work.

It is very important for pre-service teachers to initiate and be willing to do practical work on teaching experience. This not only grows their confidence but also gives them the experience of what is expected in the school curriculum that some teachers and schools take for granted.

The mentor teachers were also interviewed and given a questionnaire regarding practical work. As this allowed the researcher insight into what teachers do in schools.

Table 4.6: Teachers Questionnaire Analysis (from Teacher's Questionnaire in Annexure 1)

Teacher	Q1 Agree or Disagree	Q2 Agree or Disagree	Q3 Agree or Disagree	Q4 Agree or Disagree	Q5 Agree or Disagree	Q6 Agree or Disagree
1.	A	A	A	A	A	D
2.	A	D	A	A	A	A
3.	A	D	A	A	A	A
4.	A	A	A	A	A	D
5.	A	D	A	A	A	A
6.	A	A	A	A	A	D
7.	A	A	A	A	A	D

Analyzing the table above from Annexure 1 the Teacher's Questionnaire, looking at the first question all teachers agreed that they need to modify lessons according to the resources

available. This goes back to the B.Ed course where pre-service teachers are shown how to improvise and use materials that are easily attainable and inexpensive.

Question 2 involved encouraging peers to conduct practical work of which 3 teachers agreed and 3 disagreed, meaning that not many teachers enjoy doing what their peers have to suggest or it could be lack of interest, resources or even the teacher's confidence. If a peer is assisting then this will make practical work easier and confidence can always be achieved by practicing. Laboratory assistance plays an important role and makes practical work easy to conduct, however not all science teachers have this luxury. Cook and Taylor (1994) suggested the employment of laboratory assistants as a means of solving maintenance problems. It is clear that in the B.Ed 4th year course most of the apparatus is set up for the pre-service teachers making it easy and convenient to do practical work. Whereas in most schools all responsibility is placed on the teacher. This can be overwhelming especially when the apparatus is expensive.

All teachers agreed that experience boosts confidence levels but this cannot be achieved if no effort is made or initiative taken. All teachers agreed that the purpose of school practical work is to confirm scientific theory which is exactly what the lecturer's objective was. Both systems have the same objective but not always the same outcome. All teachers agreed that they follow step-by-step procedures when doing scientific investigations which in my opinion shows order and organization when carried out appropriately.

Question 6 was the one question that worried me with regards to what actually happens in classrooms during practical activities. Three of the six teachers agreed that they adjust results when the practical does not go as planned. The reason for doing this also pressures teachers from the department's perspective where they are given memos to follow, (Annexure 6). This is referred to by Kirschner et.al (2006) by giving an example in math "coaching students about correct responses in math, for example, may impair their ability later to retrieve correct responses from memory on their own". This means that if a teacher is guiding a learner more than what is expected it can have a negative impact on the practical work being done. By not allowing students to come up with reasons as to why their results are incorrect can be a very disturbing way of dealing with practical work that sometimes does not give the result that is expected. Learners are experimenting and many factors can affect that situation. Those factors need to be explained and not adjusted to save time. By giving learners the answers we are not creating scientists or even making them think as such which means that as teachers we

are failing in practical work. This failure is then carried to tertiary level where practical work is viewed and practiced differently.

Table 4.7: Mentor Teachers interview analysis

Questions	MT1	MT2	MT3	MT4	MT5	MT6	MT7
1. Do you give your learners' practical work? Y/N	Y	Y	Y	Y	Y	Y	Y
2. If yes? In your opinion what are the benefits of using practical work in teaching? Benefits Y/N	Y	Y	Y	Y	Y	Y	Y
3. What in your experience is organizing practical work? Are there practical's you have found difficult to run? Y/N if so what did you do?	Y	P Y Demo	P Y Demo	P N	P N	P Y Demo	P Y
4. Do your learners enjoy doing practical work?	Y	Y	Y	Y	Y	Y	Y
5. Do you prepare your learners for design experiments?	N	N	Y	N	N	Y	Y
6. In your view are the resources of the school adequate for practical work in science? Do you get enough support to carry out practicals?	Y Y	N N	N N	Y Y	Y Y	Y N	Y Y
7. In your opinion what are the main constraints in designing and running practicals?	Time plan	Language	Plan	Time Resources	Transport	Resources Space	Time

An interview was done with each of the seven pre-service teachers as this allowed the researcher to tap into what type of mentor teachers each pre-service teacher had and how they assisted in this transition of helping the pre-service teachers in a school environment.

All mentor teachers said that they do practical work with their learners. All these teachers said that practical work benefits the learners with regards to understanding the content, "what they see, is what they remember" (MT2), "They actually understand it better when they actually doing it themselves" (MT4), "Past learners always come back to thank us for doing practical work as they see the value of it once they enter tertiary education" (MT7). I agree with MT7 and Akinbobola and Afolabi (2010) who claim that these skills

"are the aspect of science learning which is retained after cognitive knowledge has been forgotten. Using science process skills is an important indicator of transfer of knowledge which is necessary for problem solving and functional living". MT3 stressed how important practical work is "…. The more experiments that's done makes the children more focused and makes them understand and picture" however the pre-service teacher that was under his care had difficulty carrying out a practical with very little assistance.

Six Teachers agreed that planning plays a very important role in organizing practical work.

MT4 had a laboratory assistant that prepared all practical work. This saves a lot of time. MT1 also mentioned that "it takes a lot of time to set everything up". Setting apparatus can be time consuming however when pre-service teachers are at the school for experience they can be part of the teaching team and assist as well as be assisted by the mentor teacher. This allows good team work and time can be managed wisely when working together. MT2 mentioned "that each learner must have a responsibility". MT3 had a very interesting point of view. He said "it depends on the educator, because if the educator is not having enough practical work in terms of planning, there will not be any experience, that or ideas that the children can gain. So when you bring in more practical work on your own it helps in terms of strategies and materials that you will be using in teaching so that one contributes a lot". By analyzing what MT3 has said he surely should have been a good role model to the pre-service teacher with regards to planning and organizing and allowing the pre-service teacher to observe and partake in how practical work is done in a classroom. MT6 viewed organizing practical work in a very different way from the other teachers'. To this teacher "it's just to gather the pieces of information and to ensure learners can visualize whatever theory they have learnt, and the practical's it needs to include in some of the things that are not covered and learners must see whatever is happening and try to visualize how to come up with their own, how to use this thing out of class". This teacher seemed as if organization depended on information given rather than doing an actual practical. If practical work includes things that are not covered are you explaining this to your learners? Should learners be experimenting out of class? Safety precautions? Is this explained? In my opinion MT7 explained it nicely. He said that "if you can give learners' a set of guidelines and the appropriate equipment, chemicals if they need, that in my opinion is already organizing practical work, even if it's something they don't end up writing about". MT6 and MT7 have complete opposite

views of this. MT6 views it as writing information and MT7 views it as allowing learners to experiment being given the materials and no write up. Every teacher can do things differently but this can cause some hindrance in the learning process of practical work. Looking at these two teachers views one can clearly see that the pre-service teachers had very different experiences regarding there mentor teachers given. MT6 left his pre-service teacher to do things on his own with minimum assistance and hardly interacted whereas MT7 assisted his pre-service teacher throughout the teaching experience which made the experience valuable.

Five mentor teachers admitted that they had found difficulties with some practical work. However this did not stop them from doing practical work. MT1 and MT2 got learners to assist them. By allowing learners to assist this allows then to actively participate and also shows good organization. MT3 mentioned resources a limiting factor and MT5 mentioned that experience made the practical's easier to do. MT6 got his facilitator to help and also manipulated the practical to make it easier for his learners to understand and do. MT7 mentioned factors such as time, and the equipment and chemicals being used can be difficult to monitor when learners are busy with regards to safety precautions. Pre-service teachers need to know these factors and experience so that they are aware of what barriers and difficulties can occur in schools and also what precautions must be taken as a teacher with regards to safety.

Three teachers preferred demonstrations rather than allowing the learners to conduct the practical work themselves. MT2 and MT3 found that it was a challenge monitoring the learners especially when chemicals were used so they prefer doing demonstrations. MT3 and MT6 mentioned that resources were limited and therefore demonstrations were conducted. However ST2 who had MT2 as a mentor teacher did an amazing job with the practical conducted and also he really made time and effort to get all the apparatus by himself from the university. This shows hard work and determination for success in his career as well as a dedicated teacher that managed on his own as his mentor teacher was keener on demonstrations.

All the teachers agreed that their learners enjoyed doing practical work.

Designing of experiments was only mentioned by MT3 and MT7 where MT7 says his learners are given "a choice as to what we are going to investigate… I make them plan". MT7 gives his learners 'guiding questions'. "They can research… I require them to give

me a progress report. The progress report is basically a write up about what do I need and how am I going to use it, and what safety precautions are applicable. I can then recognize major problems and guide them". Some teachers really go out of the curriculum and challenge there learners by entering them into competitions this is where design and plan plays an important role.

MT2 and MT3 had limited resources however MT2 was more concerned about teachers wasting or being neglectful rather than allowing teachers to use the apparatus. "We actually do have a lot of resources but it is not well kept". MT3 "We do have resources but the problem is as time goes on we do use them and our department we find it difficult to buy this apparatus…. Lack of funds". MT2 had a pre-service teacher that went beyond the classroom to make a success of his practical lesson. MT2 could have assisted his pre-service teacher knowing he had equipment but did not. Here is where the B.Ed 4th year course comes with what the pre-service teachers are equipped with. The right mind set and motivation can make you a wonderful teacher that goes beyond the classroom to help your learners understand and enjoy the subject of physical science.

The main constraints in designing and running practicals from the 7 teachers include: (1) Time, (2) Planning, (3) Language, (4) Resources, (5) Transport and (6) Space. This all can be eradicated if proper planning is in place and as science teachers they can all work as a team. Mentor teachers are aware of limiting factors yet some refused to make an effort. During my travels to Europe I noticed that while visiting science museums it wasn't just tourists that enjoyed these settings but parents and children of all ages. I also noticed that the kids were familiar with the people working there as some were there teachers and this could be the game changer when in a classroom. These kids get to see their teachers doing what they love in a different environment but it also shows professional development and interaction. By being more involved in practical activities outside the environment a teacher can motivate learners to enjoy the practical work in a classroom and also have much to offer to pre-service teachers when on teaching experience.

4.6 Summary

Looking back at the research questions we find that for research question 1 theory and practical must link in order to achieve learning and practice. The higher the quality of teachers produced, more effective teaching in classrooms will take place. This higher quality

of teachers involves teachers furthering their studies, knowing their subject well and interacting with other fellow scientists enhance their pedagogy skills (Ogunmade, 2005).

Research question 2 reflects on the importance of these practical activities carried out by the pre service teachers that most of them agreed assisted them during Teaching Experience. These practical activities allow the pre service teachers to be more confident when carrying out practical work however there are challenges when doing it in a classroom as mentioned before.

Research question 3 concerns the pre service teachers' perceptions of doing practical work during teaching experience. It is more challenging as most schools lack apparatus and there are many learners in one classroom. Time is a major factor and group work does not always go as planned. Teachers in schools are not very helpful and there is no one to assist setting up a practical activity.

Research question 4 deals with skills being transferred from the B.Ed 4th year course to the school. As the lecturers mentioned that this course is not just designed for the South African matric system but rather for further studies and other systems that can allow teachers to go beyond SA and teach. Although the B.Ed 4th year course has proven to allow pre service teachers to go into schools and teach, these pre service teachers still seem to lack confidence. As confident as they are when doing experiments in the B.Ed course they tend to lose focus in a school due to change of environment and different peer interactions. Support is vital for this transfer to take place. The pre service teachers that gained that support from there mentors were confident and successful with their objectives.

4.7 Conclusion

Looking at the results holistically, I find that the gap between the B.Ed.4th year course and school results in many factors that affect pre-service teachers and confuses them as to what is actually expected. Factors such as language, safety, assistants, expectations, pre-service teacher's general pedagogical content knowledge and resources change the game of both environments.

Firstly, one has to look at the B.Ed 4th year course as this is where it all begins. Lecturers A and B both had very clear intentions and views about what is expected in the course. However this course is deficient in incorporating the reality of school life. There are two

types of curriculums that were referred to in this research: the B.Ed. curriculum and the school curriculum. Each one of them plays its own role and differs vastly. The curriculum of B.Ed 4th year and the curriculum of school are similar and yes the B.Ed 4th year has to have more than what is expected in a classroom and is competent with all two curriculums mentioned earlier. This curriculum is set by the lecturer and not a department and therefore time constraints work in favor of the course whereas in schools teachers are expected to complete a syllabus set by the department. The B.Ed 4th year course is set to run in a certain way whereby practical work is organized and all equipment is available for the practical activities included. This shows good planning and practical's are tested before they are done by the students in order to gain expected results and also to test if the equipment is working. This fortunately enough is done by laboratory demonstrators and the laboratory technician who makes sure that all laboratory equipment is available and in working order. The demonstrators also make sure that all safety precautions are taken when using apparatus by making students aware before the practical begins. All students in fourth year complete a first aid course which is compulsory in the science department. Also all students are not allowed in the laboratory without a laboratory coat and this serves as a safety precaution as well as a type of status that science students have.

Language as stressed above plays an important role in the manuals given to the students as well as the instructions given by the demonstrator. In fourth year lecturers take it for granted that students are able to understand academic writing as well as follow instructions. Unfortunately the challenge here is that science as a language that can be understood by all scientists across the world but language in itself especially when it is a second language makes a subject difficult to teach and understand sometimes. It is evident in the pre-service teachers' laboratory reports that most of them did not include diagrams and error analysis when they were asked to. Students must familiarize themselves with all apparatus and also know the names and functions the apparatus is used for especially all safety hazards. Fakudze and Rollnick (2008) suggest different learning styles that can assist teachers and learners' crossing borders into the science subject. Firstly they mention that the materials the teacher uses and the way she/he speaks and makes use of everyday language and academic language is important as this could allow learners' to differentiate between the two (Fakudze & Rollnick 2008). In this way the learners' language and the teachers language meets somewhere and together they can produce or work towards an academic social language. These different tactics and learning styles have no boundaries when it comes to teaching and

learning. Visuals, technology, analogies metaphors etc. are just a few ways of making learning exciting and interesting and also making it easy for a learner to understand difficult concepts. Science language as seen in Table 4.3 affects many students in the writing up of reports and also recognizing dependent and independent variables (Annexure 2) if one doesn't understand what these variables are.

Student-teachers are the most affected by both environments unfortunately and this is done unintentionally. The B.Ed 4th year course strives to produce the best of science teachers but this is not always achieved as when these students enter schools they are pressured by the realities of school life. These pressures include the schools they choose and the department expectations. TE (Teaching experience) is one of the most stressful times for student-teachers. How they are expected to teach from a university expectation to how they teach in a school setting varies tremendously. The B.Ed 4th year course looks at aspects concerning content and practical work very closely and therefore student-teachers are expected to show both in one lesson that they are examined on. Many student-teachers go back to teaching the way they were taught as this is the easier approach. However from the 6 teachers 3 chose demonstrations and the others did practical work with the learners. Student-teachers are challenged with time which they are not use to at a university level. They also struggle with resources as well as expectations of what their mentor teacher expects. Resources are easily available for student-teachers as the university accommodates for them to use the equipment on teaching experience. Dealing with forty or more learners can be overwhelming. Discipline can be a major issue and so is safety with regards to the learners. Another major issue is that of assistance. In a school the teacher is expected to do everything.

The way we think influences the way we speak and vice versa, (Boroditsky, 2011). Student-teachers still struggle with language in their fourth year and this is clearly visible in their laboratory reports (Annexure 5). Besides struggling with language in their studies they sometimes struggle on teaching experience (TE) and tend to code-switch a lot during a lesson to make the practical easy to understand and follow. The language used in class is that of science but one has to understand the instruction and problem in order to comprehend and act. Many teachers code-switch as this allows them to get things done quicker. George Orwell stated that the language you speak determines the way that you will interpret the world around you and that language merely influences your thoughts about the real world (Orwell, 1984).

Teachers in schools with experience tend to handle practical work more easily and professionally. However the curriculum seems to be demanding and many teachers do not have the time to complete the syllabus and therefore tend to do practical work on weekends in order to save time but also complete the practical with ease and less time constraints. Again teachers have no assistants and this means that the teacher has to set up and plan the practical in such a way that there are minimum problems and the learners are able to complete in the time given. Resources play a major role in many schools where some schools are well equipped and others are not. Some schools have laboratories and others don't. Teachers need to make the effort to make every opportunity a learning experience. Teachers 'are also aware that not all practical work is exciting and fun. As argued by Abrahams (2009) teachers' are limited in the number of fun practical tasks to do that has a 'whiz', 'bang 'or 'pop 'that can be used every day. It is rather an image that science puts forward that it should be exciting and fun to do but instead the actual tasks at times are said to be boring.

A teacher's PCK (Pedagogical Content Knowledge) plays an important role here regarding the student-teacher and the teacher herself/himself. As a teacher one is a role model and student-teachers tend to learn from those with experience. The gap between school and the B.Ed 4th year course lies in the fact that student-teachers need to be placed in a realistic situation and learn to adapt to it in order to gain experience and deal with the realities of practical work in a school based setting. They also need to become more aware of the dangers they face when dealing with learners and how important it is to be vigilant and have safety rules put forward. Not all practicals go as planned and time is a major factor in schools. Student-teachers need to deal with this by planning in advance and also getting to know their learners in order for effective practical work to take place.

Chapter 5: Conclusion

5.1 Introduction

Chapter one provided the reader with background to this study and was based on how practical work enhances learner understanding. Practical work was looked at from a South African based school curriculum.

Chapter two dealt with the review of literature around practical work. Literature showed that practical work does enhance understanding only if it is effectively facilitated. Many aspects were looked at such as time, lack of resources, history and philosophy of science, language and inquiry based learning. After looking at all these aspects, a teacher has to be well trained for effective learning to take place.

Chapter three dealt with the research design and methodology. Qualitative method was used which resulted in a lot of information gained which had to be coded and transcribed for optimum analysis to be made. As large amounts of data were collected from the participants this allowed the researcher to cross check questions for trustworthiness.

Chapter four looks at the data collected and finds that many factors affect pre-service teachers when doing practical work and allows a gap between the B.Ed and school. Instead of looking at each institution separately pre-service teachers need to combine their experiences and use their skills to the best of their ability.

Chapter five concludes the research by looking at each research question in its element and what was achieved by this research that can benefit both pre-service and future mentor teachers.

Throughout the chapters, I have argued on the importance of practical work for science teaching and learner acquisition of science concepts. I have also argued that pre-service teachers need to be prepared enough to teach practical work. I based my study on how 4th year science B.Ed course prepares pre-service teachers to incorporate practical work in their teaching. This chapter is designed to provide the reader with an overall and summary of the findings. I start by providing the summary of findings looking at each research question. I then move to limitations of the study. I then provide recommendations and areas of further research emerging from my study.

5.2 Summary of results

RQ1: What is it that lecturers say about the objectives of the Physical Sciences IV course?

Firstly, this was done through interviewing lecturers who teach Physical Science IV course to 4th years. There was alignment in both lecturers'' utterances. They all gave clear aims and objectives of the course and further explained that the course is designed to help pre-service teachers gather all the necessary skills that they need to teach science in schools. In most of their utterances, they referred to the course in relation to the methodology course and argued that pre-service teachers are trained to see the link between theory and practical. In general, the lecturers understood the aims of the course. One thing that emerged is that they did not *only* plan to equip pre-service teachers with what is in the CAPS document. The course was designed to go beyond that so that they could train teachers who are more knowledgeable.

Secondly, what lecturers prepared for students seemed to be in line what they say. The lab manuals went beyond just letting pre-service teachers perform practical work. Pre-service teachers had to manipulate apparatus and engage with what they were doing. Although one could argue that what is on the manual does not necessarily transfer to the actual thing, what pre-service teachers did showed some way of meeting lecturers' objectives.

Thirdly, the practical work that was given to pre-service teachers were not inquiry-based. Inquiry-based investigations are desired because they are open-ended and allow students to critically think about what they want to do.

RQ2: What practical activities are carried out by pre-service teachers? What is the importance of these practical activities according to the pre-service teachers?

All the practical work done in the B.Ed 4th year course is relevant and also allows pre-service teachers to think beyond just school work. Once these teachers enter schools even if they had forgotten certain aspects of the course the practical part should still be remembered as it is important for solving problems and functional living (Akinbobola & Afolabi, 2010).

Practical work is not just putting the apparatus together when seen, but it needs planning, designing a problem, creating a new approach and procedure and also putting familiar things together in a new arrangement. This implies that the knowledge of creativity exhibited by candidates in any practical class helps them to manipulate some practical equipment (Akinbobola & Afolabi, 2010).

Evidence shows that all practical activities carried out by the B.Ed 4th years enhanced their skills and allowed them to carry out practical work in a school environment with minimum problems. The importance of these activities were the skills acquired.

RQ3: What are the perceptions of B.Ed 4th year Physical Science teachers with regards to practical activities during their teaching experience?

Pre-service teachers' conceptions about practical work were in some-way linked to what the lecturer' say about the aims and objectives of the course.

- Firstly, most of the pre-service teachers claim that they are able to design their own experiments. This raises some questions in terms of how they handle apparatus when teaching practical work. For example, when one is able to design their experiment, they should know names of all apparatus. Although this contradicts what they do in schools, it aligns with the aims and objectives of the PS IV course. One of the things that the lecturers said was that they would like to develop practical skills in pre-service teachers to an extent where they are able to design and perform experiments on their own. However, perceptions do not necessarily mean implementation.
- There seems to be a mutual feeling amongst pre-service teachers about working in groups when they do practical work. Pre-service teachers voiced that they prefer working in pairs if not alone. Pedagogically speaking, this is acceptable. Groups work does not always result in effective learning and therefore denying pre-service teachers to learn the skills of doing practical work. On the other hand, one could argue that this is part of team work and it is one of the things that practical work enhances. This team work unfortunately is not available always in schools as individuals vary.
- When pre-service teachers were asked about how practical work they are doing links with the theory, uncertainties emerged. Pre-service teachers in Table 4.4 claimed that the theory did not link to the practical but later admitted that sometimes application is more difficult than bookwork. Maybe this is because it is not made explicit. Although lecturers strongly feel that what they do theoretically is linked to practical, it is not the case with pre-service teachers.

RQ4: How are practical skills transferred from B.Ed to a school context?

Findings from observing pre-service teachers doing practical work reveal that they engaged more in what the curriculum required them to do. There was not enough evidence that pre-service teachers would engage their learners in open-ended experiments/investigation

It was found that pre-service teachers need more practice with regards to setting up laboratories and also having the correct chemicals ready knowing all safety precautions. Pre-service teachers were not well prepared in terms of this. This is because the technicians set up apparatus for the pre-service teachers before the practical activity. They also need to work with bigger classes so that they are able to carry out practical work as well as maintain discipline. By introducing the hazard sheet to first years carrying into fourth year, this will create awareness to what students are exposed to and also it will make them more aware when they are on TE. Here the mentor teacher plays a very important role with regards to transferring the B.Ed skills to the classroom with ease and guidance.

By referring to Dale's Cone of Experience we can understand how much attention is given to something when you can hear, see, say, write and do. When one is actually taking part in the practical not just for interest sake or for examinable purposes, but rather to gain an understanding as well as be part of a community of scientists it changes your view of what you should do and how you should do it. This study clearly showed a relation between the B.Ed 4th course and school. However this course can be improved with regards to certain aspects. Although the course is structured well and all aims, objectives and skills targeted are clear and relevant to the course, the course does expose pre-service teachers to teaching experience in schools, however even though pre-service teachers are exposed to school life it is for a very short period of time. Although the B.Ed has a short fall of the reality of school, mentor teachers complete the transition of taking a pre-service teacher from ideal to actual.

Evidence showed that skills are transferred from B.Ed to school through acquiring, understanding, learning and practicing.

5.3 Limitations of the study

- Sampling: this study explored students from one university who are in the same year of study. For this point, results in this study cannot be generalized but they can shed a light on experiences that pre-service teachers encounter when doing practical work.

5.4 Recommendations and further research

This study can be researched further looking into interesting issues regarding safety precautions and introducing the BEd IV years to be placed in schools besides for teaching experience and assist teachers with the practical work component. This will also enhance school performance as teachers will have assistants and learners will be easier to manage with the pre-service teachers benefiting and improving their practical skills with regards to an actual school situation. The B.Ed IV years as part of methodology or an assignment, work as a group at Scibono or any other science fair to develop a programme for a week for science learners that can broaden their idea of practical work and increase their confidence.

The B.Ed IV course will be producing more efficient and confident teachers as they will know what to expect when they enter schools and also make them aware of their own laboratory work and what they should be paying attention to. Another important factor is to get the 4th years involved in their TE to help schools conduct practical work. I feel that this component of TE should be included separately for 4th year students. This will allow students to be more confident and prepared as to what is expected once they have qualified.

5.5 Efficiency of the Research Design

What was gained and achieved in this research? The methodology approach used in chapter three allowed the researcher to look beyond just the questions and answers of this research. By collecting a vast amount of data this required a lot of time transcribing videos and interviews which can be frustrating. However the success outweighs the frustrations with regards to the research questions. The research design used allowed the researcher to answer the research questions to the best of her ability with the data collected. It would be interesting to do the same research using a different way, by following pre-service teachers from year 1 to being a mentor teacher.

References:

Abd-El-Khalick, F. & Lederman, NG. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education, 22* (7), 665 – 701.

Abrahams, I & Saglam, M. (2010). A Study of Teachers' Views Towards Practical Work in Secondar Schools in England and Wales. *International Journal of Science Education, 32* (06), 753-768.

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education, 30* (14), 1945-1969.

Abrahams, I. (2009). Does Practical Work Really Motivate? A study of the Affective Value of Practical Work in Secondary School Science, *International Journal of Science Education, 31*(17), 2335-2353.

Abrahams, I., & Reiss, M. J. (2012). Practical work: Its effectiveness in primary and secondary schools in England. *Journal of Research in Science Teaching, 49* (8), 1035-1055.

Akinbobola, O. A., & Afolabi, F. (2010). Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria. *American-Eurasian Journal of Scientific Research 5* (4), 234-240.

Alexander, P. A. (1997). Mapping the multidimensional nature of domain learning: The interplay of cognitive, motivational, and strategic forces. *Advances in motivation and achievement, 10,* 213-250.

Alfieri, L., Brooks, P.J., Aldrich, N.J., Tenenbaum, H.R. (2011). Does discovery-based instruction enhance learning.

Ali, M. & Ismail, Z. (2006). Comprehension level of non-technical terms in science: Are we ready for science in English. *Jurnal Pendidik dan Pendidikan*, 21, 73-83.

Baker, D. R. (2016). Equity issues in science education. In *Understanding Girls* (pp. 127-160). Sense Publishers.

Baldo, J., Dronkers, N. F., Wilkens, D., Ludy, C., Raskin, P., & Kim, J. (2004). Is problem solving dependent on language. *Science Direct: Brain and language*.

Baird, J. R. (1990). Metacognition, purposeful enquiry and conceptual change. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum* (pp. 183-200). London: Routledge.

Bandura, A. (1986). Social Foundations of Thought and Action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bennett, J. (2003). *Teaching and Learning Science: A guide to recent research and its applications*. London: Continuum.

Berg, B. L. (1989). Qualitative research methods for the social sciences. Needham Heights, Massachusetts: Allyn & Shuster.

Bodner, G. M., & McMillan, T. L. B. (1986). Cognitive restructuring as an early stage in problem solving. *Journal of Research in Science Teaching, 23(*8), 727-737.

Boroditsky, L. (2011). How Language Shapes Thought. The languages We Speak Affect Our Perceptions of the World. *Scientific American, 304*,62-65.

Bose, A. & Choudhury, M.(2010). Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australia. Fremantle: MERGA.

Brand, R. B., & Glasson, G. (2004). Crossing cultural borders into science teaching: Early Life Experiences, Racial and Ethnic Edentities, and Beliefs about Diversity. *Journal of Research in Science teaching*, 119-141.

Brodie, G. (1978). The role of the laboratory in the education of industrial physicists and engineers. In J.G. Jones & J.L. Lewis (Eds), *The role of the laboratory in physics education* (pp.4-14). Oxford, UK. ICPE/GIREP.

Brown, S. J., Collins, A., & Duguid, P. (1989). Situated Cognition and the culture of Learning. *Educational Researcher, 18* (1), 32-41

Clackson, S. G., & Wright, D. K. (1992). An appraisal of practical work in science education. *School Science Review, 74* (266), 39-42.

Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education, 27*(4), 471-486.

Cresswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed methods approaches*. Los Angeles: Sage.

Collette, A. T. & Chiappetta, E. L. (1989). *Science instruction in the middle and secondary schools* (2nd Ed.). Mwrrill Publishing Company: London.

Conteh, J. (2000). Multilingual classrooms, standards and quality: Three children and a lot of bouncing balls. *Language and Education, 14*(1), 1-17.

Cummins, J. (2007). Rethinking monolingual instructional strategies in multilingual classrooms. *Canadian Journal of Applied Linguistics/Revue canadienne de linguistique appliquée, 10* (2), 221-240.

Dale, E. (1954). *Audio-Visual Methods in Teaching*. NY. Dryden Press.

Dale's cone of learning. (2015, September 15). HLWIKI Canada,. Retrieved 19:45, March 26, 2016 from http://hlwiki.slais.ubc.ca/index.php?title=Dale%27s_cone_of_learning&oldid=142135.

Deci, E. L. (1992). The relation of interest to the motivation of behaviour: A self-determination of theory perspective. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), The role of interest in learning and develoment (pp. 43-70). Hillsdale, NJ: Lawrence Erlbaum Associates.

Department of Basic Education (2011a). *Curriculum and Assessment Policy Statement Grade 10-12*. Government Printing Works.

Dillon, J. (2008). A review of the research on practical work in school science. *King's College, London*, 1-9.

van Driel, H. J., Beijaard, D & Verloop, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching, 38* (2), 137-158.

Dufficy, P. (2001). Scaffolding and assisted performance in multilingual classrooms. *Journal of Educational Enquiry*, 33-49.

Edelson, D. C., Gordin, N. D., & Ray, D. P. (1999). Addressing the challenges of Inquiry-Based Learning Through Technology and Curriculum Design. *Journal of the Learning Sciences*, 8 (3-4), 391-450.

Fakudze, C., & Rollnick, M. (2008). Language, Culture, Ontological Assumptions, Epistimological Beliefs, And Knowledge About Nature And Naturally Occurring Events: Southern African Perspective. *Educational Studies in Language and Literature, 8 (1),* 69-94.

Ferreira, J.G. 2011. Teaching life sciences to English second language learners: What do teachers do?. *South African Journal Of Education,*31,102-113.

Galili, I. & Hazan, A. (2001). Experts' Views on Using History and Philosophy of Science in the Practice of Physics Instruction. *Science and Education, 10,* 345-367.

Gee, J. P. (1997). Thinking, Learning and reading. *Situated cognition: Social, semiotic and psychological perspectives*, 102-111.

Gega, P. C. (1994). *Concepts and experiences in elementary school science*. MacMillan Publishing Company.

Gieryn, T. F. (1983). Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideoligies of Scientists. *American Sociological Review, 48* (6), 781-795.

Gunstone, R. F., & Champagne, A. B. (1990). Promoting conceptual change in the laboratory. In E. Hegarty-Hazel (Ed.), The student laboratory and the science curriculum (pp. 159-182). London: Routledge.

Gwee, S.B.Y. (2006). Teacher Code-Switching in a Multilingual Classroom. National Institute of Education/ Nanyang technological University.

Gyoung, Y. & Mijung, K. (2010). Collaborative Reflection Through Dilemma Cases of Science Practical Work during Practicum, *International Journal of Science Education, 32* (3), 283-301.

Halliday, M. A. K., & Martin, J. R. (1993). Towards a language-Based Theory of Learning – The Laboratory of Comparative Human Cognition. Linguistics and Education, 5, 93-116.

Hannan, Dr. A. (2007). Questionnaires in Educational Research.

Haug, B., & Odegaard, M. (2014). Budding Science and Literacy. A classroom Video Study of the Challenges and Support in an Integrated Inquiry and Literacy Teaching Model. Procedia – Social and Behavioural Sciences, 167, 274-278.

Henderson, J., & Wellington, J. (1998). Lowering the language barrier in learning and teaching

science. *School Science review*, 35-46.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 70* (256), 33-40.

Hodson, D. (1996). Practical work in school science: exploring some directions for change. *International Journal of Science Education, 18* (7), 755 – 760.

Hodson, D. (1991). Practical work in science: Time for a reappraisal. *Studies in Science education, 19*, 175-184.

Hodson, D. (2007). Experiments in science and science teaching. Educational Philosophy and theory, 20(2), 53-66.

Hofstein, A., & Lunetta, V. N. (1980). *The role of the laboratory in science teaching research implications*. Washinton: Eric Clearinghouse.

Hofstein, A., & Lunetta, V.N. (1982). The Role of the Laboratory in Science Teaching. Neglected Aspects of Research. *American Educational Research Association. Review of Educational Research 52* (2), 201-217.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science education, 88* (1), 28-54.

Hogstrom, P., Ottander, C. & Benckert, S. (2010). Lab work and learning in secondary school chemistry: the importance of teacher and student interaction. *Research in Science Education*, 43, 1107-1245.

Hottecke, D., Henke, A., & Riess. (2010). Implementing History and Philosophy in Science Teaching: Strategies, Methods, Results and Experiences from the Eoropean HIPST Project. *Science and Education, 10,* 1-29.

Howie, S. J. (2003). Language and other background factors affecting secondary pupils' performance in Mathematics in South Africa. African Journal of Research in SMT Education, 7, 1-20.

Hurd, P.D, 1969, *New Directions in Teaching Secondary School Science*, Rand McNally and Company, Chicago

Ian Abrahams (2009) Does Practical work Really Motivate? A study of the affective value of practical work in secondary school science, International Journal of Science Education, 31:17, 2335-2353, DOI: 10. 1080/09500690802342836.

Ian Abrahams, Murat Saglam. A study of teachers'views towards practical work in secondary schools in England and Wales. International Journal of Science Education, Taylor & Francis (Routledge), 2010, 32 (06), pp. 753-768. <10.1080/09500690902777410>. <hal-00582126>.

Kirschner, P. (1992). Epistemology, practical work and academic skills in science education. *Science & Education, 1*(3), 273-299.

Kirschner, P.A., Sweller, J. & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist, 41* (2), 75-86.

Kriek, J. & Basson, I. (2008). Implementation of the new FET Physical Sciences curriculum: teachers' perspectives. African Journal of Research in Mathematics, Science, and Technology Education, 12, 63-76.

Langley, M. (2014). Supporting teachers and technicians in the delivery of high-quality, effective practical science. *SSR, 96* (355).

Lave, J. (1996). Teaching, as learning, in practice. *Mind Culture and Activity, 3* (3), 149-163.

Lave, J., & Wenger, E. (1991) *Situated Learning: Legitimate peripheral participation* (pp.13-24). Cambridge, Cambridge University Press.

Lichtman, M. (2006).*Qualitative Research in Education: A user's Guide*.United Kingdom: Sage

Loucks-Horsley, S., Kapitan, R., Carlson, M. D., Kuerbis, P., Clark, R. C., Melle, G. M., T. P., & Walton, E. (1990). *Elementary school science for the '90s. Alexandria*. VA: Association for Supervision and Curriculum Development.

Loughran, J., Mulhall, P., Berry, A. (2004). In Search of Pedagogical Content Knowledge in Science: Developing Ways of Articulating and Documenting Professional Practice. *Journal Of Research In Science Teaching, 41,* 370-391.

Manyak, P. C. 2004. "What did she say?" Translation in a primary grade Englisg immersion class. Multicultural erspectives, 6, (12-18).

Matthews, M. R. (1992). History, philosophy, and science teaching: The present rapprochement. *Science and Education, 1,* 11-47.

Maxwell, J. A. (1992). Understanding and validity in qualitative research. Harvard Educational Review, 62(3), 279-300.

Millar, R. (2004). *The role of practical work in the teaching and learning of science*. National Academy of sciences, Washington, DC.

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.

Mokiwa, H. H. & Msila, V. (2013). Teachers' conceptions of teaching physical science in the medium of English: A case study, *International Journal of Educational Sciences,* 5 (1), 55-62.

Morrell, P. D. ,& Carroll, J. B. (2010). *Conducting Educational Research: A primer for Teachers and administrators*. New York: Sense Publishers.

Muwanga-Zake, J.W. F. (1998). Applications of Computer-Aided Assessment in the Diagnosis of Science Learning and Teaching. *International Journal of Education, 2* (4).

Nesbit, C. R., Hargrove, T. Y., Harrelson, L., & Maxey, B. (2004). Implementing science notebooks primary grades. *Science Activities: Classroom Projects and Curriculum Ideas, 40*(4), 21-29.

D.C. Scientific investigations: The effect of the 'Science Notebooks' approach in Grade 6 classrooms in Port Elizabeth South Africa.

Ogunmade, T. O. (2005). The status and quality of secondary science teaching and learning in Lagos State, Nigeria. Retrieved from http://ro.ecu.edu.au/theses/86

Opie, C. (Ed). (2004) *Doing Educational Research.* Sage. London. Chapter 5. Research procedures. Pp. 111 – 120.

Orwell, G. (1984). The Sapir-Whorf Hypothesis.

Oyoo, S. (2009). Beyond general proficiancy in language of instruction: Towards the Appropriate Perspective on Language for Effective Learning in African Science Classrooms. Proceedings (Refereed) of the 17th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education (SAAMSTE 2009), (1), 197-212.

Oyoo, S. O. (2012). Language in science classrooms: An analysis of physics teachers' use of and beliefs about language. *Research in Science Education,* 42, 849-873.

Pedaste, M., Maeots, M., Siiman, L.A., de Jong, T., van Riesen, S.A.N., Kamp, E.T., Manoli, C.C., Zacharia, Z.C. & Tsourlidaki, E. (2015). Phases of Inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14, 47-61.*

Pekmez, E. S., Johnson, P., & Gott, R. (2005). Teachers' understanding of the nature and purpose of practical work. *Research in Science & Technological Education, 23* (1), 3-23.

Perkins-Gough, D. (2007). The status of the science laboratory, special report. *Educational Leadership*, 93-94.

Postman, N., & Weingartner, C. (1971). Teaching as a Subversive activity.

Preston, C. (2015). Effect of a science diagram on primary students' understanding about magnets, *Research in Science Education.* DOI 10.1007/s11165-015-9484-8

Probyn, M.J. 2005. Proceedings of the 4th International Symposium on Biligualism. Learning science through two languages in South Africa.*Cascadilla Press, Somerville, MA.*

Ramsey, G. A., & Howe, R. W. (1969). An Analysis of Research Related to Instructional Procedures in Elementary School Science [microform]. Science and Children, 6(7), 25-36.

Ramnarain, U. (2011). Teachers' use of questioning in supporting learners doing science investigations. *South African Journal of Education, 31,* 91-101

Ramnarain, U., & Fortus, D. (2013). South African physical sciences teachers' perceptions of new content in a revised curriculum. *South African Journal of Education, 33* (1), 1-15.

Renninger, K. A. (1998). The roles of individual interest (s) and gender in learning: An overview of research on preschool and elementary school-aged children/students. In *Interest and learning: Proceedings of the Seeon conference on interest and gender* (pp. 165-174).

Rogan, J., & Grayson, D. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25* (10), 1171-1204.

Rollnick, M. (2000). Current issues and Perspectives on Second language Learning of Science. *Studies of Science Education,* 93-121.

Schiefele, U. (1996). Topic interest, text representation, and quality of experience. Contemporary Educational Psycology, 12, 3-18.

Seah, H. L, Clarke, D. J. & Eugene, C. (2014). Understanding the language demands on science students from an integrated science and language perspective. *International Journal of Science Education,* 36 (6), 952-973.

Shamos, M. H. (Ed.). (1960). Great experiments in physics. New York: Holt, Rinehart and Winston.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4–14.

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

Staer, H., Goodrum, D., & Hackling, Dr. M. (1998). High School Laboratory work in Western Australia: Openness to inquiry. Research in Science Education, 28(2), 219 – 228.

Stoffels, N.T. (2005). "There is a worksheet to be followed": a case study of a science teacher's use of learning support texts for practical work. *African Journal of Research in Mathematics, science and Technology Education, 9,* 147-157.

Tamir, P. (1989). Training teachers to teach effectively in the laboratory. *Science and Education, 73,* 59-69.

Tamir, P. (1972). The practical mode a distinct mode of performance. Journal of Biological Education, 6, 175-182.

Taylor, N., & Prinsloo, C. (2005). The quality Learning Project Lessons for High School Improvement in South Africa.

Thair, M. & Treagust, D. F. (1999). Teacher Training Reforms in Indonesian Secondary Science: The Importance of Practical Work in Physics. Journal of Research in Science Teaching. 36(3), 357-371.

Tiberghien, A. (2000). Designing teaching situations in the secondary school. In R. Millar, J. Leach, & J. Osbourne (Eds.), Improving science education: The contribution of research (pp. 27-47). Buckingham, UK: Open University Press.

Toplis, R. & Allen, M. (2011). 'I do and I understand? Practical work and laboratory use in United Kingdom Schools. *EURASIA Journal of Mathematics, Science and Technology Education, 8* (1), 3-9

Treagust, D. F., Chittleborough, G., & Mamiala, T. L. (2003). The role of submicrpscopic and symbolic representations in chemical explanations. International Journal of Science Education, 25(11), 1353-1368.

Villanueva, M. G., & Webb, P. (2008). Scientific investigations: The effect of the 'Science Notebooks' approach in grade 6 classrooms in Port Elizabeth. *South African Journal of Research in SMT Education, 12* (2), 3-16.

Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press. Chapter 6 (pp. 79-91).

Wilkinson, J., & Ward, M. (1997). A Comparative Study of Students' and Their Teacher's Perceptions of Laboratory Work in Secondary Schools. Research in Science Education, 1997, 27(4), 599 – 610.

Woolnough, B. (1991). Practical Science: The role and reality of practical work in school science. Open University Press

Annexure 1

TEACHER INTERVIEW

AIM OF LABORATORY WORK

1. Do you give your learners' practical work?
2. If yes? In your opinion what are the benefits of using practical work in teaching?
3. What in your experience is organizing practical work? Are there any practicals you have found to be difficult to run? If so what did you do?
4. Do your learners' enjoy doing practical work. If so, why do you think they like/dislike practicals?
5. How do you prepare your learners for design experiments?
6. In your view are the resources of the school adequate for practical work in science? Do you get enough support to carry out practicals. Why?
7. In your opinion what are the main constrains in designing and running practicals.

Questionnaire:

TEACHERS QUESTIONNAIRE

Please answer all items of this questionnaire. We would like to know your views, this is not a test. Your answers will be used for educational research purposes only. Your response will be treated confidentially: your identity will not be revealed and is known only to the researcher.

Please respond to each item in the space provided

1. I am to choose or modify science lessons based on what resources I have available.

   I agree: I disagree:

   _____
   _____
   _____
   _____

2. I encourage my peers in physical science to conduct practical work in lessons.

   I agree: I disagree:

   _____
   _____
   _____
   _____

3. Experience develops your confidence in carrying out practical work.

   I agree: I disagree:

   _____
   _____
   _____
   _____

4. The purpose of school practical work is to confirm scientific theory.

   I agree: I disagree:

   _____
   _____
   _____
   _____

5. There is a step-by-step procedure for doing all scientific investigations

I agree: I disagree:

_____
_____
_____
_____

6. When the results of a demonstration experiment carried out by a teacher are unexpected and do not confirm the theory, he/she should adjust them in order to confirm the theory.

I agree: I disagree:

Student Teachers' Questionnaire

1. What is your opinion on practical work in the B.Ed course?
2. Do you design your own experiments? Give reasons
3. What condition is the laboratory equipment in?
4. Is the theory you do in class related to the practical work?
5. Do you prefer working with peers or on your own when conducting practical work? and why?
6. Describe your learning environment.
7. What was your ideal laboratory experience

STUDENT TEACHER INTERVIEW

AIM OF LABORATORY WORK

1. Tell me about your experiences with physical science courses in middle-high school and college. Lab experiences?
2. What is your opinion on practical work in the B.Ed coursed?
3. What condition is the laboratory equipment in?
4. Is the theory you do in class related to the practical work?
5. Do you design your own experiments? (Give reasons)
6. What effect does working with peers have on your practical work?
7. Describe your learning environment.
8. What was your ideal laboratory experience?
9. Tell me about your experiences with physical science courses in middle-high school and college. Lab experiences?
10. How well do you think your pre-service teacher education (practical work in physical science) prepared you? What are some things you feel well prepared to do and things you feel you are not very prepared to do?

Lecturers Interview

1. What are the objectives of the practical work chosen in 4th year physical science?

The objectives are for the students to link their theory to what happens in nature as well as to understand better the theories they learn in lectures through hands on experience. Also this allows students a chance to be able to use the different equipment available for physical science practicals.

2. What criteria was used to select the PS4 practical's?

The practicals should be linked to their theory in class and the equipment available in the labs. The practicals should allow the students to engage with the theory not just reproduce it.

3. What skills are targeted in this course?

Students should improve their creative skills, reasoning skills, problem-solving skills, graphing, and other skills.

4. How are the PS 4 practical's designed?

First look at the topic to be taught and look for practicals around those areas which match the equipment available in the lab or to be bought. The practicals chosen should also be linked to everyday life events if possible.

5. How do the selected practical's in the PS4 course relate to the CAPs document?

The aim is for students to be able to:

(a) Gain active and critical learning: skills by encouraging an active and critical approach to learning, rather than rote learning
(b) Gain high knowledge and high skills
(c) Identify and solve problems and make decisions using critical and creative thinking
(d) Work effectively as individuals and with others as members of a team;
(e) Organise and manage themselves and their activities responsibly and effectively;
(f) Collect, analyse, organise and critically evaluate information;
(g) Communicate effectively using visual, symbolic and/or language skills in various modes;
(h) Use science and technology effectively and critically showing responsibility towards the environment and the health of others

6. How are the skills targeted in the PS4 course transferred to a school context?

The students are encouraged to be familiar with all equipment so that they can be able to perform the experiments at their schools. They learn similar skills from different experiments to

show that it is the standard to use even at matric level. During TE some of the skills are assessed and encouraged for students to show before they finish their degrees.

7. Why are practical's included in the PS4 course?

To show that physical science is a practical subject were theory and practice should e gained simultaneously.

8. Are the practical's selected considered to be relevant to whom and why?

Yes they are considered to be relevant as there is comparisons with other universities locally and internationally. The practicals are always linked to the theory so they are relevant as the theory is relevant. The practicals are meant to reinforce the theory being taught

Annexure 2

Table 4.1: Results of lecturers' interview about the objectives of the course

What are the objectives targeted in selecting PS IV practical work?	
Lecturer A	**Lecturer B**
The objectives of practical work in PS IV are highlighted. To elaborate on them, they are: a) To reinforce theory content taught in the lecture and to give students opportunities to link this theory with practical observation. This is especially important as it enables the students to then ponder more on what they have learnt b) To refine their skills of experimental design, which they will need as teachers, to help prepare their students for practical exams. c) To assist students to develop an effective response to science. The more familiar they are with the tools of Physics, the more confident they will be as teachers, and the more effective their teaching will be.	The objectives are for the students to link their theory to what happens in nature as well as to understand better the theories they learn in lectures through hands on experience. Also this allows students a chance to be able to use the different equipment available for physical science practical work.
What criteria are targeted in selecting PS IV practical work?	
Lecturer A	**Lecturer B**
The criteria used were: a) Relevance to subject content taught b) Innovation – substituting components with locally available, inexpensive materials c) Exposure to high quality Physics Equipment similar to apparatus actually used by scientists – to bring about familiarity with the processes of Physics.	The practical work should be linked to their theory in class and the equipment available in the labs. The practical work should allow the students to engage with the theory not just reproduce it.

What skills are targeted in selecting PS IV practical work?	
Lecturer A	**Lecturer B**
The PS IV course targets three main skills for Physics teachers: a) Content competency – thorough knowledge of the subject content and topics in the course. b) Mathematical modelling and cognitive manipulation skills – handling and analysis of Physics equations and how to interpret them, and manipulation of data using graphical and other representations	Students should improve their creative skills, reasoning skills, problem-solving skills, graphing, and other skills.

c) Practical and safe handling of equipment skills. Familiarity and confidence in using scientific equipment, ability to read and interpret measuring scales, awareness of accuracy and precision constraints, and innovation – being able to find appropriate representations using local inexpensive materials.	

How the PS IV are practical's designed and how do these practical activities selected relate to the CAPS documents?	
Lecturer A	**Lecturer B**
I use web-based resources, textbooks and WITS main campus, practical physics handbooks in designing these practical's. After selecting the central concept of the practical, and the focus, I consult these resources to find out what practical work have been carried out in respect of the central concept. I then use more than one source to design and come up with a practical suitable for the central concept and main focus. The PS IV practical work are not necessarily or deliberately related to the CAPS document because the aim of the course is not to train teachers solely for the SA Matric system. We also want our teachers to be competent practitioners in the IEB and the A-level systems as well. The overriding criteria for selecting practical work is relevance to the subject content taught. I believe that if teachers find themselves teaching these topics in the CAPS curriculum, they can then design and use the same practical's that they learned during training. This will make them more confident in delivering their work – but this applies equally to IEB and A-level teaching	First look at the topic to be taught and look for practical's around those areas which match the equipment available in the lab or to be bought. The practical's chosen should also be linked to everyday life events if possible. The aim is for students to be able to: (a) Gain active and critical learning: skills by encouraging an active and critical approach to learning, rather than rote learning (b) Gain high knowledge and high skills (c) Identify and solve problems and make decisions using critical and creative thinking (d) Work effectively as individuals and with others as members of a team; (e) Organize and manage themselves and their activities responsibly and effectively; (f) Collect, analyze, organize and critically evaluate information; (g) Communicate effectively using visual, symbolic and/or language skills in various modes; (h) Use science and technology effectively and critically showing responsibility towards the environment and the health of others

How are the practical skills transferred from B.Ed to a school context?	
Lecturer A	**Lecturer B**
If the students can master the skills taught as I described in answer to your first question, they will be able to design and run practical sessions with their students at school, safely and effectively.	The students are encouraged to be familiar with all equipment so that they can be able to perform the experiments at their schools. They learn similar skills from different experiments to show that it is the standard to use even at matric level. During TE some of the skills are assessed and encouraged for students to show before they finish their degrees.

Why are practical's included in the B.Ed program?	
Lecturer A	**Lecturer B**
The PS IV Physics course is designed for several purposes: a) To develop Physics teachers who are competent to teach secondary science up to Matric, A-level and IEB matriculation levels. As such the course must be robust and cover materials that go deep enough to satisfy the requirements of the three examining boards in South Africa b) To achieve this goal, the students must not only be exposed to the content knowledge, but also to the practical knowledge of how scientists go about the development of their knowledge. The course utilizes several avenues of learning and tries to engage both hemispheres of the brain in the process of learning. i.e. cognition, tactile manipulation , prediction and pattern making, as well as holistic visualization c) The practical's included in the course serve three main purposes: i) To represent content knowledge learnt in a practical way – i.e. to reinforce content knowledge through experimentation ii) To refine the skills of observation, manipulation and experimental design – i.e. to engage with the tacit knowledge informing the scientific enterprise iii) To enhance students appreciation of Physics as a human activity and to expose them to the challenges inherent in the development of scientific knowledge d) Lastly, The PS IV course is designed in such a way that there is an underlying core theme linking all the topics together. Practical work provides the students with opportunities to identify this core theme by engaging with similar concepts in a practical manner. In addition, it is the lecturer's strong belief that science is a practical subject and that for a long lasting impression, students must be engaged in all their senses. As the Chinese say: Hear and forget; See and remember; Do and understand.	To show that physical science is a practical subject were theory and practice should be gained simultaneously.

Are these practical's considered to be relevant?	
Lecturer A	**Lecturer B**
They are relevant to the subject taught. This links with the first objective that I mentioned earlier	Yes they are considered to be relevant as there is comparisons with other universities locally and internationally. The practical work are always linked to the theory so they are relevant as the theory is relevant. The practical work are meant to reinforce the theory being taught.

- Electricity and Magnetism

Assessment Taxonomy

Application exercises should be done at all cognitive levels in all knowledge areas.

Refer to Appendix 1 for the assessment taxonomy at cognitive levels one to four.

Recommended Informal Assessment

1. Give learners at least two problem-solving exercises on a frequent basis (every day as far as possible). These should collectively cover all cognitive levels and could be done as homework and/or class work.
2. Learners should do at least ONE practical activity per term.
3. Learners should be given at least ONE informal test per term.

NOTE

- **Informal assessment tasks** are homework, class work, practical investigations, experiments and informal tests.
- Informal assessment tasks **will assess** structured problem solving involving calculations, practical investigations, experiments, projects, scientific arguments, ability to predict, observe and explain. Informal assessment tasks should also include problem-solving exercises that do not involve calculations.
- **Formal assessment tasks** are control tests, examinations, experiments and projects.
- "**Practical activities**" as used in this document will refer to practical demonstrations, experiments or projects used to strengthen the concepts being taught.
- "**Experiment**" will refer to a set of outlined instructions for learners to follow in order to obtain results to verify established theory.
- "**Practical investigations**" will require learners to go through the scientific process.

2.3 TIME ALLOCATION OF PHYSICAL SCIENCES IN THE CURRICULUM

The teaching time for Physical Sciences is 4 hours per week, with 40 weeks in total per grade. The time allocated for the teaching of the content, concepts and skills includes the practical work. These are an integral part of the teaching and learning process.

GRADE	NO. OF WEEKS ALLOCATED	CONTENT, CONCEPTS & SKILLS (WEEKS)	FORMAL ASSESSMENT (WEEKS)
10	40	30	10
11	40	30	10
12	40	29	11

2.4 OVERVIEW OF TOPICS

Topic		Content
Mechanics	Grade 10	**Introduction to vectors & scalars; Motion in one dimension** (reference frame, position, displacement and distance , average speed, average velocity, acceleration, instantaneous velocity, instantaneous speed, description of motion in words, diagrams, graphs and equations.) **Energy** (gravitational potential energy, kinetic energy, mechanical energy, conservation of mechanical energy (in the absence of dissipative forces)) **30 hours**
	Grade 11	**Vectors in two dimensions** (resultant of perpendicular vectors, resolution of a vector into its parallel and perpendicular components), **Newton's Laws and Application of Newton's Laws** (Newton's first, second and third laws and Newton's law of universal gravitation, different kinds of forces: weight, normal force, frictional force, applied (push, pull), tension (strings or cables), force diagrams, free body diagrams and application of Newton's laws(equilibrium and non-equilibrium)) **27 hours**
	Grade 12	**Momentum and Impulse** (momentum, Newton's second law expressed in terms of momentum, conservation of momentum and elastic and inelastic collisions, Impulse), **Vertical projectile motion in one dimension (1D)** (vertical projectile motion represented in words, diagrams, equations and graphs), **Work, Energy & Power** (work , work-energy theorem, conservation of energy with non-conservative forces present, power) **28 hours**
Waves, Sound & Light	Grade 10	**Transverse pulses on a string or spring** (pulse, amplitude superposition of pulses), **Transverse waves** (wavelength, frequency, amplitude, period, wave speed, **Longitudinal waves** (on a spring, wavelength, frequency, amplitude, period, wave speed, sound waves), **Sound** (pitch, loudness, quality (tone), ultrasound), **Electromagnetic radiation** (dual (particle/ wave) nature of electromagnetic (EM) radiation, nature of EM radiation, EM spectrum, nature of EM as particle - energy of a photon related to frequency and wavelength) **16 hours**
	Grade 11	**Geometrical Optics** (Refraction, Snell's Law, Critical angles and total internal reflection), **2D & 3D Wave fronts** (Diffraction) **13 hours**
	Grade 12	**Doppler Effect (either moving source or moving observer)** (with sound and ultrasound, with light - red shifts in the universe.) **6 hours**
Electricity & Magnetism	Grade 10	**Magnetism** (magnetic field of permanent magnets, poles of permanent magnets, attraction and repulsion, magnetic field lines, earth's magnetic field, compass), **Electrostatics** (two kinds of charge, force exerted by charges on each other (descriptive), attraction between charged and uncharged objects (polarisation), charge conservation, charge quantization),**Electric circuits** (emf, potential difference (pd), current, measurement of voltage (pd) and current, resistance, resistors in parallel) **14 hours**
	Grade 11	**Electrostatics** (Coulomb's Law, Electric field), **Electromagnetism** (Magnetic field associated with current-carrying wires, Faraday's Law), **Electric circuits** (Energy, Power) **20 hours**
	Grade 12	**Electric circuits** (internal resistance and series-parallel networks), **Electrodynamics** (electrical machines (generators, motors), alternating current) **12 hours**
Matter & Materials	Grade 10	**Revise matter and classification** (materials; heterogeneous and homogeneous mixtures; pure substances; names and formulas; metals and non-metals; electrical and thermal conductors and insulators; magnetic and nonmagnetic materials). **States of matter and the kinetic molecular theory. Atomic structure** (models of the atom; atomic mass and diameter; protons, neutrons and electrons; isotopes; energy quantization and electron configuration). **Periodic table** (position of the elements; similarities in chemical properties in groups, electron configuration in groups). **Chemical bonding** (covalent bonding; ionic bonding; metallic bonding). **Particles substances are made of** (atoms and compounds; molecular substances and ionic substances). **28 hours**
	Grade 11	**Molecular structure** (a chemical bond; molecular shape; electronegativity and bond polarity; bond energy and bond length). **Intermolecular forces** (chemical bonds revised; types of intermolecular forces; states of matter; density; kinetic energy; temperature; three phases of water (macroscopic properties related to sub-microscopic structure)). **Ideal gases** (motion and kinetic theory of gases; gas laws; relationship between T and P) **24 hours**
	Grade 12	**Optical phenomena and properties of materials** (photo-electric effect, emission and absorption spectra) **(6 hours for physics) Organic chemistry** (functional groups; saturated and unsaturated structures; isomers; naming and formulae; physical properties; chemical reactions (substitution, addition and elimination). **Organic macromolecules** (plastics and polymers) **16 hours**

Topic		Content
Chemical Systems	Grade 10	**Hydrosphere 8 hours**
	Grade 11	**Lithosphere** (mining; energy resources) **8 hours**
	Grade 12	**Chemical industry** (fertilizer industry). **6 hours**
Chemical Change	Grade 10	**Physical and chemical change** (separation by physical means; separation by chemical means; conservation of atoms and mass; law of constant composition).**Representing chemical change** (balanced chemical equations). **Reactions in aqueous solution** (ions in aqueous solutions; ion interaction; electrolytes; conductivity; precipitation; chemical reaction types) **Stoichiometry** (mole concept). **20 hours**
	Grade 11	**Stoichiometry** (molar volume of gases; concentration; limiting reagents; volume relationships in gaseous reactions) **Energy and chemical change** (energy changes related to bond energy; exothermic and endothermic reactions; activation energy). **Types of reactions** (acid-base; redox reactions; oxidation numbers **28 hours**
	Grade 12	**Reaction rate** (factors affecting rate; measuring rate; mechanism of reaction and of catalysis). **Chemical equilibrium** (factors affecting equilibrium; equilibrium constant; application of equilibrium principles). **Acids and bases** (reactions; titrations, pH, salt hydrolysis). **Electrochemical reactions** (electrolytic and galvanic cells; relation of current and potential to rate and equilibrium; standard electrode potentials; oxidation and reduction half reaction and cell reactions; oxidation numbers; application of redox reactions). **28 hours**
Skills for practical investigations	Grade 12	Skills for practical investigations in physics and chemistry. **4 hours**

2.5 OVERVIEW OF PRACTICAL WORK

Practical work must be integrated with theory to strengthen the concepts being taught. These may take the form of simple practical demonstrations or even an experiment or practical investigation. There are several practical activities outlined alongside the *content, concepts and skills* columns throughout **Section 3.** Some of these practical activities will be done as part of formal assessment and others can be done as part of informal assessment. Below is a table that lists prescribed practical activities for formal assessment as well as recommended practical activities for informal assessment across grades 10 to 12.

CONTENTS

	Page
Laboratory rules	**2**
Course outline	**5**
Introduction to EDUC 4144	15
Physics cover page	20
Practicals	**21**
1. Demonstration experiment 1: How a thermometer works	21
1. Investigating the change of state of water and Naphthalene	22
2. Demonstration experiment 2: Can you tell hot from cold – Effect of heat	27
2. To investigate the heating curve of water	28
3. Demonstration experiment 3: Measuring Calories	33
3.1. Specific Heat Capacity of Water	34
3.2. Specific Heat Capacity of copper turnings by method of Mixtures	37
4. Demonstration experiment 4: Why do we not use metal handles?	39
4. Thermal Expansion of Water	40
5. Demonstration experiment 5: Measure your reaction time	46
5.1. Rate of Heat Flow within a Metal	48
5.2. Investigating Boyle's Law	52
6.1. The Cathode Ray Oscilloscope	55
6.2. An Electrical SHM Oscillator – Using an LCR circuit	61
7. Demonstration experiment 6: Making a Spectroscope	64
7.1. Investigating Emission and Absorption Spectra of different Materials	65
7.2. Atomic Spacing in a metal	69
8. Example of a Practical Test	71
Tutorials	**73**

Annexure 5:

Laboratory reports

Do not write in this margin

Question .....
Write on both sides of the paper

Do not in th marg

what are you discussing?

Discussion

First trial (1)

$$\frac{\Delta T}{T} = \sqrt{\frac{\Delta g}{g} + \frac{\Delta \ell}{\ell}}$$

$\Delta g = 0,003 + 1,0$
$= 1,003$

$\Delta \ell = 0,1 + 0,01$
$= 0,11$

$$\Delta T = \sqrt{\frac{\Delta g}{g} + \frac{\Delta \ell}{\ell}} \times T$$

$$= \sqrt{\frac{1,003}{0,003} + \frac{0,11}{0,1}} \times 0,7$$

what is the actual?

$= \sqrt{334,3 + 1,1}$

$\Delta T = 18,3$

Are you calculating percentage error? what is the accepted?

Trial 2

$\Delta g = 0,0015 + 1,0$
$= 1,0015$

$$\frac{\Delta T}{T} = \sqrt{\frac{1,0015}{0,0015} + \frac{0,21}{0,2}}$$

$\Delta \ell = 0,2 + 0,01$
$= 0,21$

$\Delta T = 25,8 \times 1,1$
$= 28,3$

Trial 3

$\Delta g = 0,0027 + 1,0$
$= 1,0027$

$$\frac{\Delta T}{T} = \sqrt{\frac{1,0027}{0,0027} + \frac{0,04}{0,3}}$$

$\Delta \ell = 0,3 + 0,01$
$= 0,04$

$\Delta T = \sqrt{371,5} \times 1,2$
$= 23,1$

Do not write in this margin

Question .....
Write on both sides of the paper

Do not in th marg

what are you discussing?

Discussion

First trial (1)

$$\frac{\Delta T}{T} = \sqrt{\frac{\Delta g}{g} + \frac{\Delta \ell}{\ell}}$$

$\Delta g = 0,003 + 1,0$
$= 1,003$

$\Delta \ell = 0,1 + 0,01$
$= 0,11$

$$\Delta T = \sqrt{\frac{\Delta g}{g} + \frac{\Delta \ell}{\ell}} \times T$$

$$= \sqrt{\frac{1,003}{0,003} + \frac{0,11}{0,1}} \times 0,7$$

what is the actual?

$= \sqrt{334,3 + 1,1}$

$\Delta T = 18,3$

Are you calculating a percentage error? what is the accepted?

Trial 2

$\Delta g = 0,0015 + 1,0$
$= 1,0015$

$$\frac{\Delta T}{T} = \sqrt{\frac{1,0015}{0,0015} + \frac{0,21}{0,2}}$$

$\Delta \ell = 0,2 + 0,01$
$= 0,21$

$\Delta T = 25,8 \times 1,1$
$= 28,3$

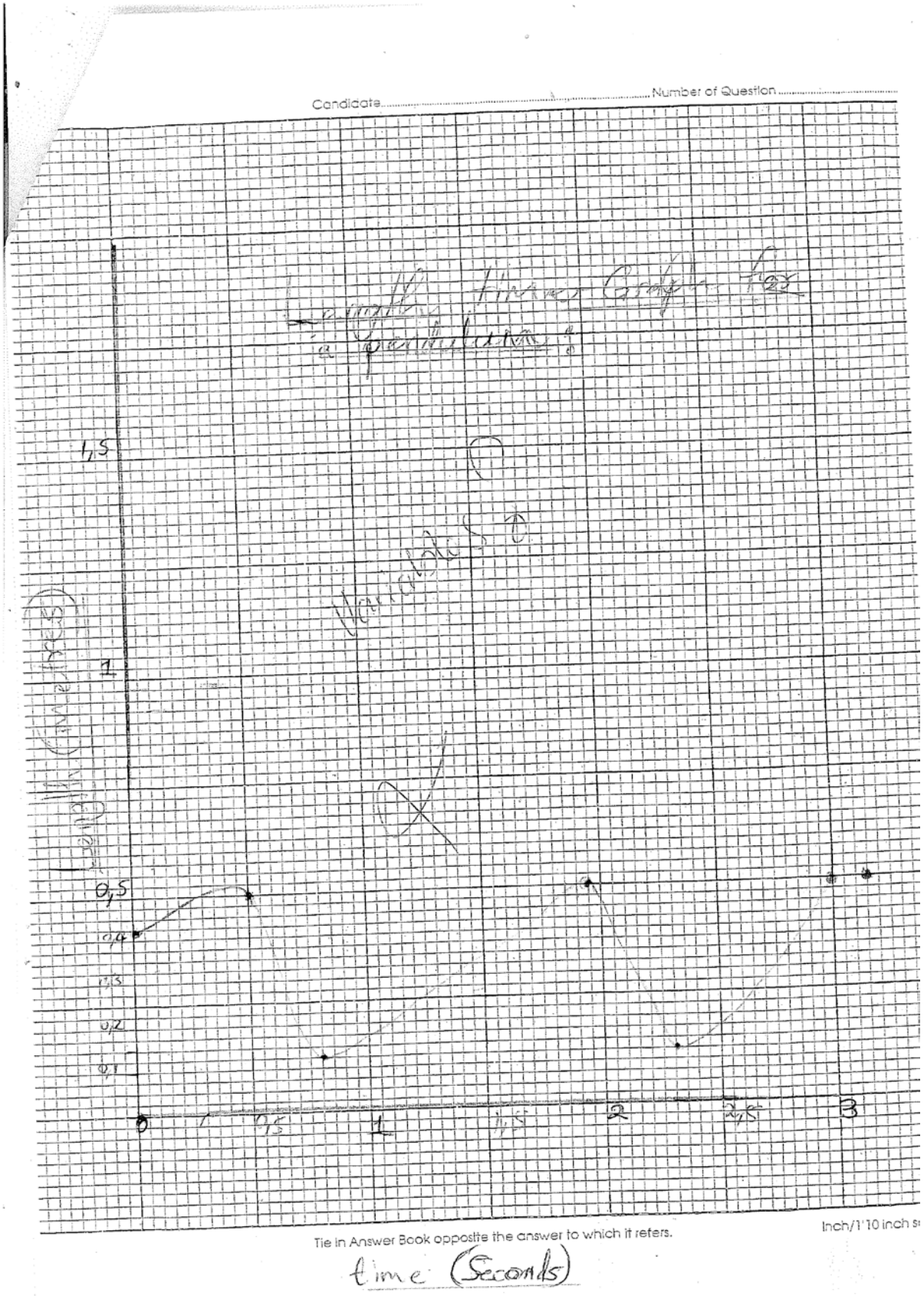
Trial 3

$\Delta g = 0,0027 + 1,0$
$= 1,0027$

$$\frac{\Delta T}{T} = \sqrt{\frac{1,0027}{0,0027} + \frac{0,04}{0,3}}$$

$\Delta \ell = 0,3 + 0,01$
$= 0,04$

$\Delta T = \sqrt{371,5} \times 1,2$
$= 23,1$



Tie in Answer Book opposite the answer to which it refers.

Inch/1'10 inch s

Question .....
Write on both sides of the paper

Do not write in this margin

Do not w in this margir

Conclusion

Shown from the results and calculations that the relationship of the length of the pendulum is directly proportional to the period it takes the pendulum to complete a full oscillation. Therefore as length increases, so does the period it takes the pendulum to complete the full oscillation.

However, it is worth noting that gravity as a third quantity measured using the variables of length and period do not give conclusive deduction of the [illegible] further relationship that exist using this equation you [illegible] terms

$T = 2\pi\sqrt{l/g}$

But when I compare length 20 cm and 40 cm a distinction between the two calculations of the gravity is worth noting that:

l_{20} - 9.32 m/s

l_{40} - 8.17 m/s

No Graph o

that as the length was doubled, from 20 cm to 40, the value of g decreased. Therefore for particularly this calculation $l \propto 1/g$ or $T \propto 1/g$: $l_{20}(0,45) - 9.32\ m/s$ $l_{40}(1,39) - 8.17\ m/s$

did see graph

Therefore an inverse relationship exists if a further investigation was to be examined from this one is this relevant to the task you were asked.

Recommendation

A protractor has to be fixed at the point of origin, so that accurate angles can be determined & that consistant Periods can be determined. X

Do not write in this margin

Question .....
Write on both sides of the paper

Do not w in this margi

Length (cm)	time taken to complete 1 period	gravity (M/S)
30	$\frac{12}{10} = 1.2$ (S)	5.48 M/S
25	$\frac{10}{10} = 1$	6.58 M/S
20	$\frac{8}{10} = 0.8$	8.22 M/S
15	$\frac{7}{10} = 0.7$	8.05 M/S
10	$\frac{5}{10} = 0.5$	10.52 MS
5	$\frac{3}{10} = 0.3$	14.62 M/S

Incorrect unit

Calculation of (g) gravity

Incorrect formula

$g_1 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 30}{3(1.2)^2}$ = 581.3 cm/s or 5.48 m/

$g_2 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 25}{3(1)^2}$ = 657.47 cm/s or 6.58 m/

$g_3 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 20}{3(0.8)^2}$ = 822.47 cm/s or 8.22 m/s

$g_4 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 15}{3(0.7)^2}$ = 805.68 cm/s or 8.06 m/s

$g_5 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 10}{3(0.5)^2}$ = 1052.76 cm/s or 10.52 m/s

$g_6 = \frac{8(\pi)^2 L}{3T^2} = \frac{8(\pi)^2 5}{3(0.3)^2}$ = 1462.16 cm/s or 14.62 m/s

$g_{ave} = \frac{g_1 + g_2 + g_3 + g_4 + g_5 + g_6}{6}$

Do not write in this margin

Question .....
Write on both sides of the paper

Do not write in this margin

read the instruments properly or the delay to stop the watch. I tried to repeat atleast three times in each turn of the experiment and take the average in order to ensure accuracy. The instrumental errors arise from the uneven gradation of the instruments. I limited these by using the same instruments throughout. The conditional errors are these triggered by conditions of where the experiment is carried e.g. wind blowing the hanging weight, friction on where the string is attached etc.

Analysis on your graph?

Error margins

$$\Delta g = |g| \sqrt{\left(\frac{\Delta T}{|T|}\right)^2 + \left(\frac{\Delta l}{|l|}\right)^2}$$

$$= 14.81 \sqrt{\left(\frac{0.1}{1.2}\right)^2 + \left(\frac{0.01}{0.3}\right)^2}$$

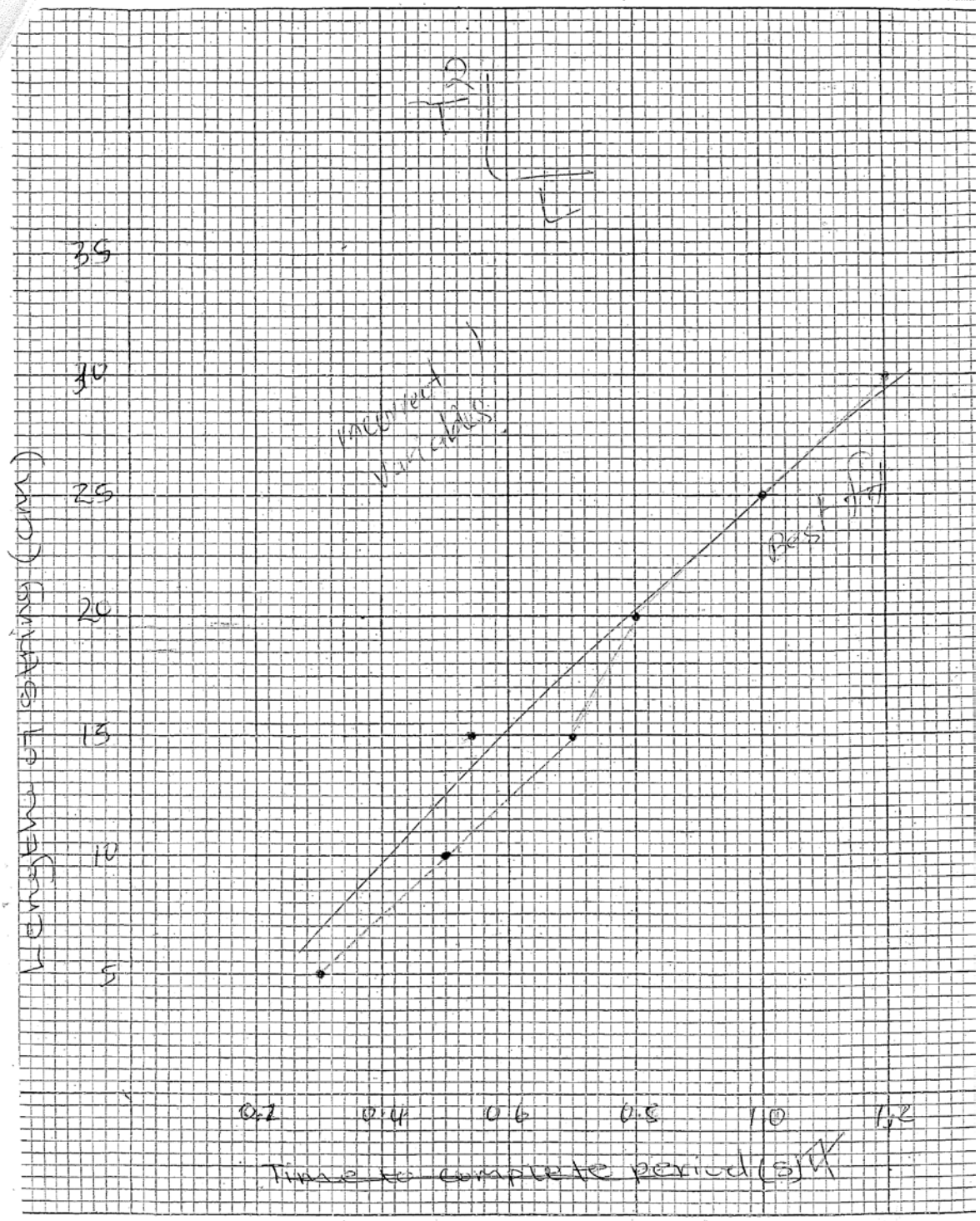
$$= 0.028 \text{ m/s}$$ — incorrect unit

Conclusion

The length of the pendulum and it's period are directly propotional. This means that as length increases

ne graph of length v.s the period time of a pendulum.

Candidate..... Number of Question .....



Tie In Answer Book opposite the answer to which it refers.

Inch/1'10 inch sc

seen by demmie

It will swing through a much smaller arc. Count how many times it takes to swing back and forth (time 40 to 60seconds)

→ Change the length of the pendulum and change the arc. Count how many times it swings back and forth using the same time.



Experiment must be carried atleast 5 to 10 times using different L

→ Record the L measurements and number of swings the pendulum made in (40 to 60s → why?

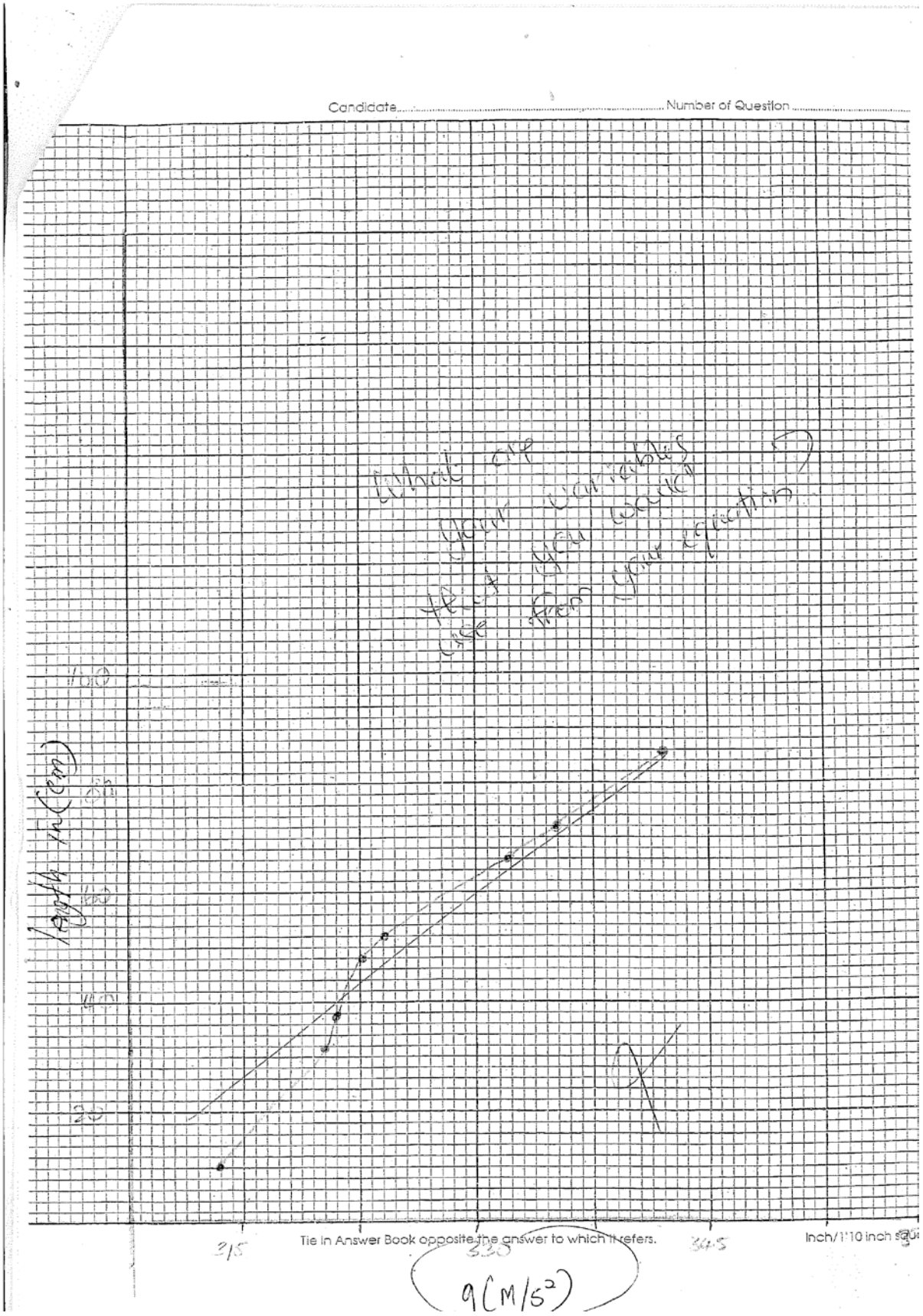
→ Calculate g using all the measurement recorded

→ find the mean g and calculate its variation

→ Use the vernier calipers to measure the diameter of the bob.

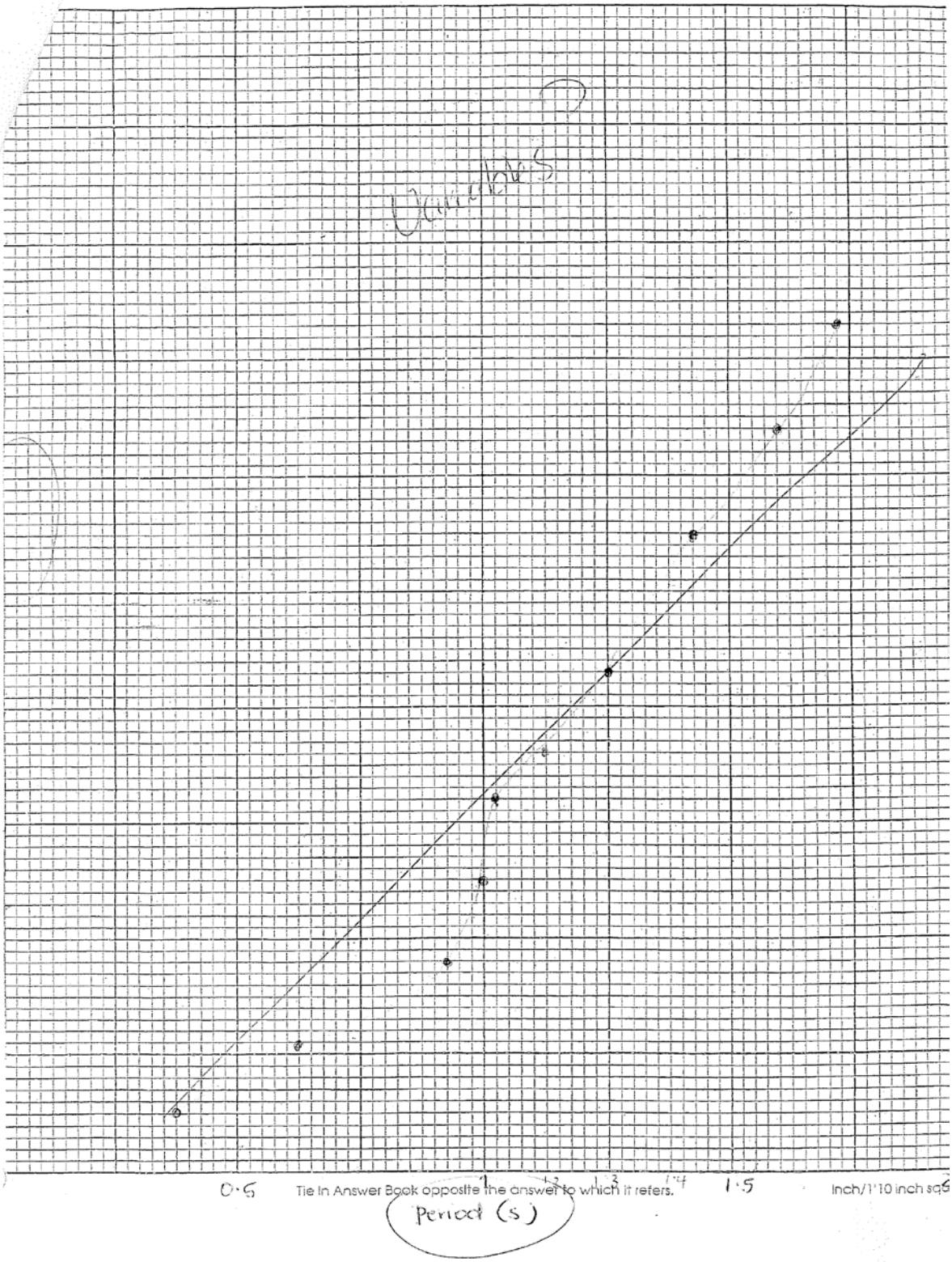
Results

length of string	length of pendulum Lp(m) = (Ls + rs)	Time for 10 Oscillation (s)	Period T (s) [time of oscillation / 10]	g for several L $g = \frac{4\pi^2 L}{T^2}$ (2) Incorrect formula	Amplitude θ
(1) 85,3cm	85,3 + 2,385 = 87,685 cm	18 seconds	$T = \frac{18}{10} = \ldots$ = 1,8 units	$g = \frac{4\pi^2(87,685)}{1,8^2}$ = 349,1 units.	20°
(2) 73,5 cm	73,5 + 2,385 = 75,885 cm	16,8 seconds	$T = \frac{16,8}{10}$ = 1,68	$g = \frac{4\pi^2(75,885)}{(1,68)^2}$ = 337,8	20°
(3) 62,3cm	62,3 + 2,385 = 64,685 cm	15,6 seconds	$T = \frac{15,6}{10}$ = 1,56	$g = \frac{4\pi^2(64,685)}{(1,56)^2}$ = 334,0	20°


Candidate
Number of Question
Length in (cm)
Tie In Answer Book opposite the answer to which it refers.
9(M/S²)

Graph representing the relationship between length and period

Candidate..... Number of Question .....



Tie In Answer Book opposite the answer to which it refers.

Inch/1·10 inch sq

Question .....
Write on both sides of the paper

Do not write in this margin

Error Analysis

Systematic error

- In my experiment it might happen that I did not use the instruments correctly which can lead to incorrect results
- The results that I got have some systematic / instrumental errors which I did not use them correctly. eg. protractor.

Personal error

In my experiment I found it difficult to read some of the instruments which can make my results to be inaccurate.
eg for a length it happened that ~~I misread~~ I read incorrectly.
In some instances I failed to read time accordingly which can affect my results.

Conclusion

In my results I found that length of a Pendulum is indirectly proportional to period. The longer the string the longer it takes to complete a period. — You contradict by your statement.

Question .....
Write on both sides of the paper

Do not write in this margin

Reducing errors

- Repeat steps several times
- Use instruments that are closer to the ~~Value~~ e.g for measurements in m I ~~should~~ use a metre rule that is in metres instead of using the one in ~~centimetres~~ centimetres.
- Try ~~to~~ read the readings more than once in order ~~to get to~~ to get correct readings

3. Recomendations

~~The~~ relationship between a ~~pendulum~~ length of a pendulum and a period, ~~The~~ length of a Pendulum is inversely proportional ~~to~~ period based on the results there I got in my expirriment

Some Clocks lose time because of the longer time they take to complete a period
Clocks lose time after a long period of time.

Question .....
Write on both sides of the paper

Do not write in this margin

$$\Delta R = \sqrt{\left(\frac{\Delta L}{|L|}\right)^2 + \left(\frac{\Delta T}{|T|}\right)^2} \times |R|$$

$$\Delta R = \sqrt{\left(\frac{1cm}{30}\right)^2 + \left(\frac{1s}{0,12}\right)^2} \times 9,8$$

$\Delta R = 81,67$ ✗ Should this not be a percentage?

Conclusion

The length of a pendulum affects the time period as it is varied: ~~the~~ shorter the length, the shorter the time period it takes for a pendulum to complete one oscillation and the longer the ~~string~~, the longer the time taken to complete one oscillation. The angle at which the mass is suspended also affects the time period, varying the angle result in different time period since this affects the oscillation. Mass and gravitational acceleration affects the time taken to complete an oscillation, however if the mass is varied because gravity is constant. for more precision and accuracy, correct instruments must be used and the correct reading of these instruments must be taken into account, this includes using ~~right~~ correct significant figures and conversions of units (to SI units).

Annexure 6: CAPS documents memos

6.3 ELECTRICITY AND MAGNETISM

PART 1: DETERMINE THE INTERNAL RESISTANCE OF A BATTERY.

RESULTS

1. Table for results obtained during experiment

	TERMINAL POTENTIAL DIFFERENCE (VOLTS)	ELECTRIC CURRENT (AMPERES)
1		
2		
3		
4		
5		

CRITERIA FOR MARKING THE TABLE

Suitable number of columns and rows as dictated by variables✓

Suitable heading on the columns✓✓

Correct units for items/quantities recorded in columns✓✓

Correct sets of values of quantities under investigation✓✓✓✓✓ (10)

INTERPRETATION AND DISCUSSION OF RESULTS

2. Variables

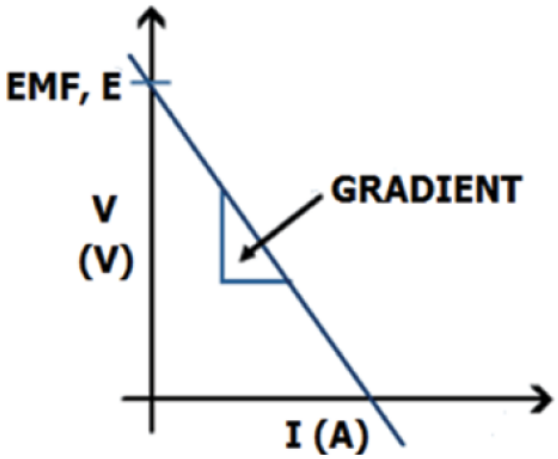
2.1 Independent: Terminal potential difference ✓✓

2.2 Dependent: Electric current ✓✓

2.3 Controlled: Temperature ✓✓ (6)

3. By changing the resistance the flowing current will be changed and the voltage as well. ✓✓ (2)

4. Graph



CRITERIA FOR MARKING THE GRAPH

- Heading of the graph✓
- Acceptable scale on the two axes✓
- Correct label of the y-axis✓
- Correct unit for the label on the y-axis✓
- Correct label on the x-axis✓
- Correct unit of the label on the x-axis✓
- Correct plotting of points based on captured data✓
- Best fitting line✓ (8)

5. Negative.✓

There is **decrease**✓ in terminal potential difference when electric current **increases**.✓ (3)

6. Gradient = $\frac{\Delta V}{\Delta I}$ Formula ✓

= ..... Substitution ✓✓

= _____ Answer ✓ (4)

7. The y-intercept on the y-axis ✓

When the current is zero✓ the terminal potential difference equals the emf,✓ because there is no internal resistance.✓ (4)

CONCLUSION

8. The stronger the current the greater the drop in terminal potential difference,✓
therefore the higher the internal resistance of the battery.✓

OR

The internal resistance can be obtained from the gradient of a potential difference versus current graph. (2)

PART 2: DETERMINE THE EQUIVALENT RESISTANCE OF A SERIES-PARALLEL NETWORK INTERPRETATION AND DISCUSSION OF RESULTS

1. $R = V/I$ Formula ✓

$= \ldots\ldots\ldots\ldots\ldots$ Substitution ✓✓

$= _____$ Answer ✓ (4)

2. $1/R_{//} = 1/R_2 + 1/R_3$ Formula ✓

$= \ldots\ldots\ldots\ldots\ldots$ Substitution ✓

$R_{//} = _____$

$R_T = R_1 + R_{//}$ Formula

$= \ldots\ldots\ldots + \ldots\ldots\ldots$ Substitution ✓✓

$= _____$ Answer ✓ (5)

CONCLUSION

3. There is a difference in the values of question 1 and 2 because of the internal resistance of the battery.✓✓

OR

The theoretical value will always differ from the calculated values. The theoretical value does not take cognisance of internal and external factors. (2)

TOTAL: 50

Annexure 7

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

26 May 2015

Student Number: 0109150E

Protocol Number: **2015ECE018M**

Dear Yasmeen Choonara

Application for Ethics Clearance: Master of Education

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:

How does the B.Eb science program prepare student teachers to teach practical work in schools during TE?

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:

- There are grammatical errors in the title of the research project in letters to participants and in the consent forms.
- These need to be corrected and assurances given by the supervisor to the Ethics Committee.
- Submission to GDE needs to be indicated
- GDE form needs to be signed

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,

M Mosetlha

Wits School of Education

011 717-3416

Cc Supervisor: Dr. Emmanuel Mushayikwa