The influence of Practical Work in the teaching and learning of acids, bases and neutrals in Natural Sciences

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DEDICATION

This thesis is dedicated to

The Almighty God

my late father, Nyanisile Festile,

My mother, Nothobile Festile,

my late brother Zingisile Michael Festile and my late sister, Yaliwe Nesther Festile

For their unconditional love with unfading support and blessings

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GLOSSARY

Abbreviations	Explanation
GET	General Education and Training
NCS	National Curriculum Statement
CAPS	Curriculum and Assessment Policy Statement
CASS	Continuous Assessment
DBE	Department of Basic Education
MST	Mathematics, Science and Technology
NDP	National Development Plan
INSET	In-Service Training
FET	Further Education and Training
PCK	Pedagogical Content Knowledge
SCORE	Science Community Representing Education
UK	United Kingdom
NESTA	National Endowment for Science, Technology and the Arts
TIMSS	Third International Mathematics and Science Study
US	United States
CASE	Computer Aided Software Engineering
CAME	Computer Aided Method Engineering
MUVE	Multi-User Virtual Environments
ICT	Information, Communication and Technology
SES	Socio-economic status
MSSI	Mpumalanga Secondary School Initiative
SMT	School Management Team

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Abstract

The purpose of this study was to determine the influence of practical work in the teaching and learning of acids, bases and neutrals, a section of the senior phase Natural Science curriculum. In regional meetings of science teachers, many teachers indicated that learners that proceed from the senior phase to the FET band have limited knowledge of science procedures, equipment and science practicals. This study takes cognisance of this dilemma highlighted by teachers and attempts to address some of the concerns raised. Three schools were purposively chosen from the same district. The sample included one class from each school. The class was taught a practical lesson in the form of collaborative teaching by the teacher, Science Centre facilitators and the researcher. A mixed method approach was used and it allowed for diverse instruments to ensure validity and reliability. Constructivism is the theoretical framework used to underpin the study. Other theories such as Pedagogical Content Knowledge (PCK) also impacted on the outcomes of this study. The findings indicated that practical work improved the results of learners and enhanced the teaching of acids, bases and neutrals. Practical work also engaged more learners even the passive ones. The key recommendation is for consistency in the practical approach to science teaching, greater emphasis on the role of practical work and the implementation of – as far as possible - a hands-on approach to science content. The study provided insights into the practical teaching of topics in natural sciences and the extent to which this approach can be used to improve learners' understanding of curriculum content.

Keywords: science education, practical work, natural science, acids and bases, constructivism

CHAPTER 1

Introduction to the study

1.1 Introduction

This chapter will provide the rationale of the study by discussing the background and context to the study, highlighting the research problem and research question. It will also identify the significance and limitations of the study.

1.2 Background

For the past few years the province of the Eastern Cape has been in the bottom three of all nine provinces as far as Physical Sciences grade 12 results are concerned. Table 1 below represents a summary of the matric results in Physical Sciences at national, provincial and district levels over the past three years. The table shows that the Physical Sciences grade 12 results have been fluctuating through the past three years. Studies done by scholars and some concerned institutions reveal that South Africa has performed poorly in Physical Sciences comparing to international standards. Howie (2003) reports that South Africa was part of the global study conducted by Trends in Mathematics and Science Study in 2001 and 2003. Makgato & Mji (2006) reports that South Africa participated in the studies that aimed at determining learner performance in the sciences in 2001 and 2003 where 38 and 58 countries respectively took part. South Africa was placed last in both instances. The persistence of the situation is affirmed by the report that between 2005 to 2007, the pass rate in Physical Sciences at the higher grade level steadily decreased which influenced their entry into science based programmes at universities (Kriek & Grayson, 2009).

A deeper research of the problem has to be conducted. Many studies have been conducted around poor performance in science subjects. With the experience that the researcher has accumulated over the years teaching at high school some of the indicators that attributed to poor performance in grade 12 Physical Sciences were witnessed. Citing but one was that learners were experiencing difficulty in a transition from primary to high school. A lot was attributed to this difficulty, one of which is the style of teaching by teachers in the General Education and Training (GET) band. In addition to this is a lack of self-confidence demonstrated by teachers with regard to the subject content of Natural Sciences. This could be where the challenge of the quality of grade 12 results of the majority of high school emanates from. As an experienced teacher who was teaching grade 12 Physical Sciences and Mathematics as well as Natural Sciences for most years the researcher joined the ranks of primary school teachers with the intention of making a contribution to improve the teaching and learning of Natural Sciences.

Table 1. Physical Science results 2012-2016

Year	National	Provincial	District
2016	62.0	49.6	65.3
2015	58.6	45.9	
2014	61.5	51.5	57.6
2013	67.4	64.9	
2012	61.3	50.4	

After attending meetings and visiting colleagues teaching Natural Sciences at primary school, the researcher witnessed that teachers at this level do not include practical work in their daily teaching. One of the greatest paradigm shifts with the introduction of both out-comes based education and the Curriculum Assessment Policy Statement (CAPS) in South African education has been from a purely examination-based exit point, to the inclusion of School-Based Assessment (SBA) (Gouws, E & Russel, Y, 2013). In South Africa post-apartheid curricula, National Curriculum Statement (NCS) and Curriculum and Assessment Policy Statement (CAPS) require that a number of investigations and practical work be done for learners to accumulate marks for continuous assessment (Cass). Because of this most teachers do only those experiments and investigations that are prescribed for moderation. This downplays the value-addition of practical work. It is important for teachers to remember that questions in examination papers are not set on the concepts in those experiments only. The CAPS in Physical Sciences in Grade 10 places greater emphasis on the use of practical work as a teaching as well as an assessment tool (DBE, 2011). Because every Natural Sciences and Physical Sciences topic has a practical application in life, practical work should be included during every topic covered in the syllabus. This could assist and encourage learners when making career choices in the science and technology arena.

Rogan (2004) indicated that there was strong evidence of the absence of practical work in science classrooms in South Africa. These authors claim therefore it is safe to assume that curriculum-aligned texts could lead to particular pedagogic pathways. This means that textbooks would be used as an alternative if not the only way to teach. This served as a good excuse for teachers who do not like to do practical work. In defence of those teachers who are not doing practical is the fact that many schools an insufficient or zero supply of science equipment. This does however not excuse the total lack of practical work as there are many elementary products that can be used to teach science concepts. In the researcher's personal experience simple apparatus like cells which cannot be preserved has to be bought every time it is to be used in an electric circuit. When teachers want to do group work they have to ask learners to buy cells when starting with current electricity lesson. Many times the teachers have to buy cells at their own cost and do demonstrations as learners would not bring them. In a study by Stoffels (2005) they found that some teachers felt that although they were constrained to application of teacher demonstrations as a result of limited resources, the demonstrations were planned to provide learners with a solid understanding of the relevant content.

1.3 The state of science education in South Africa and the Eastern Cape

The Department of Basic Education (DBE) completed a process of joining two conditional grants, namely the grants for the Dinaledi schools and for the reconfiguration of secondary schools, into one mathematics, science and technology (MST) conditional grant. This grant would be directed at making sure that schools increased the learner numbers that were doing mathematics and science and to also increase the achievement of learners. The targets set in the National Development Plan (NDP) and the MST strategies employed by the Department to meet the target was to use the two conditional grants instead of them being run separately to reach the output numbers by 2030. Some schools that were not offering mathematics and science subjects initially had already started offering those subjects at grade 10. As from January 2000, eighty-two of these schools had already started offering mathematics.

1.4 The Research problem

Land (2003) and Stoffels (2004) blamed the implementation of outcomes-based Curriculum 2005 (C2005) in South Africa for resulting in many schools to relegate the traditional content-heavy textbooks. Facilitators of workshops leading to the introduction of every new curriculum rightfully advise teachers to continue using old textbooks for references. This is the case in many schools in South African. A reason for this situation is that the post-apartheid policy message was that teachers are expected to be creative and innovative curriculum developers and able to design and develop learning materials according to the needs of their learners (Department of Education, 1998). Yet a number of studies indicate that this creative drive did not develop and that few teachers could actually do this (Rogan, 2004). This could be as a result of poor or lack of proper training for science educators.

It is generally believed that leaners learn better through practical work. This is because of the belief that we all comprehend and recollect things better if we have done them ourselves. According to Millar (2010) anyone who has experience in teaching science will know that learners often do not learn from practical work what we hope they will learn. There are research studies that support his view; hence the doubts by some if not most teachers about the contribution of practical in learning and teaching. This is supported by Osborne (1998) when he argues that practical work has a limited role to play in the learning of science and that much of it is of little educational value.

After visiting the primary schools situated in the area the researcher found that none of the schools have functional laboratories. In discussions during cluster meetings most teachers admitted that they do not perform practical work as they argue that it is time consuming, and they perform practical work when it is convenient to them, so as to comply with curriculum requirements. Even then they do it without having done thorough preparation for it. One can imagine how learners will perform in their practical work as a formal task if it was not first done during normal teaching. Practical work should be allocated in the school time table. This can in a way enforce teachers to include it in their planning.

Teachers often make no attempt at all to expand the curriculum by taking their learners out of the classroom context and identifying the curriculum content every day circumstances. It appears that the only thing they are concerned about is to cover the syllabus. In many instances, learners themselves are positive about practical work, they actually enjoy it. Dillon's (2008) is correct in his generalization that teachers who have been properly trained in Physical Sciences are comfortable and positive about practical work. These teachers see practical work as integral to teaching and learning of Natural sciences. Teachers with weak subject content knowledge are prone to adopt the structure portrayed in the texts available to them (Gess-Newsome, 1999). They are further frustrated by "too many science books" that "have different viewpoints". Teachers with a content gap find it difficult to make sense of information that is in abundance. They cannot even critique the author and take the information as it is. This is very detrimental to the future of our learners. The Department of Basic Education in South Africa generally make an effort to address such gaps by conducting content gap workshops facilitated by subject advisors. In addition to the In-Service Training (INSET) done by the Eastern Cape Universities, the University of the Western Cape is conducting a series of teacher developmental programmes in the province. The target of the programme is the FET teachers who are the base of Physical Sciences teachers and are also the sample for this study.

1.5 Research Question

Given the challenge that many science teachers have difficulty with the inclusion of practical work in the teaching of Natural Sciences concepts, this study will be directed to a specific area in Natural Sciences namely acids, bases and neutrals. The focus of the study will be in the role of practical work in the teaching of this curriculum content in Grade 7. The study will seek to explore the viewpoint of teachers and learners in the teaching of acids, bases and neutrals in grade 7. The main aim of the investigation lies in the research question which is:

How does practical work influence teaching and learning of acids, bases and neutrals in Natural Sciences?

In order to address the main research question the following research sub-questions were answered:

- What was learners understanding of acids, bases and neutrals before the practical-based lessons?
- How were the practical-based lessons implemented?
- What were learners' understanding of acids, bases and neutrals after the practical-based lessons?
- What were learners' perceptions of the practical-based lessons?
- What were teachers' perceptions of the practical-based lessons?

1.6 Rationale

Solomon (1980) stated that the teaching of science should happen in a laboratory to ensure that there will not be any misunderstanding about this issue. He further adds that teaching science belongs in the laboratory as cooking food belongs in a kitchen and gardening vegetables in the garden. Teachers are more textbook bound in our schools especially in primary school. They do not give learners the opportunity to do hands-on activities, explore and in the process learn about the work. As a result of this teachers do not see the need to explore practical work and use it as a teaching strategy. This study directed at using practical work as a teaching strategy in an attempt to provide learners an opportunity to learn curriculum content by exploring and being engaged in hands-on practical activities. The selected topic namely acids, bases and neutrals is a content area that continues up to Grade 12 in the Physical Sciences curriculum. In this study the researcher will be comparing the achievement of learners after practical work has been done while teaching acids, bases and neutrals in grade 7. This is where Grade 12 acids and bases topic foundation is laid.

1.7 Significance

The findings of the study indicated the influence of the practical work in teaching of acids, bases and neutrals in Natural Sciences. The study adds value to the teaching of Natural Sciences content by providing teachers with a detailed description of the process followed in how to use practical work in daily teaching. The study also provides curriculum advisors and education officials a crutch to stand on when promoting the practical nature of Natural Sciences. The study also provides useful baseline data about practical work in the Eastern Cape that can be used to be expanded upon in future studies.

1.8 Limitations of the study

A limitation of the study needs to include the most obvious and largest limitations first, before more complex issues are discussed. Since all research is limited by variables, adding a limitation study does not make research any less valid or important. Instead, failing to write a limitation study compromises the validity of the research.

Firstly, the research is conducted in three schools in one education district in the Eastern Cape. This has limitations in terms of generalization of the findings are concerned. Secondly, the researcher was an integral part of the team that worked with schools which could have influenced the outcomes the study, even though the researcher makes his involvement clear upfront. Because the researcher designed the type of questions to ask, he could have inadvertently influenced the results due to his own personal beliefs.

1.9 Structure of the thesis

This study is divided into five subdivisions: introduction, literature review, methodology, results and recapitulation.

Chapter 1 introduces the rationale of the study by providing the background and context of the study. It also provides the research leading into the research questions. The chapter also looks into the significance and the limitations of the study.

Chapter 2 provides the theoretical basis of the research by examining the theoretical frameworks that underpin the study. It provides a detailed literature review and considers relevant past studies that has a bearing on the research.

Chapter 3 introduces the methodology part, and covers instrument development and data collection measures. It provides a detailed data collection plan to collect the data in response to the research questions. It also addresses issues of rigour in the research.

Chapter four provides the findings of the research. It outlines a detailed analysis of the findings and presents the results in formats that facilitates the discussion of the findings.

Finally, chapter five provides an overview of the research and highlights the major findings and implications of the research. It also gives consideration to recommendations for future study and some limitations of the research.

1.10 Conclusion

This chapter provided the rationale for the study by highlighting the research problem and identifying issues that impacted on the development of the research. The next chapter will present a literature review relevant to this research.

CHAPTER 2

Literature Review

2.1 Introduction

The previous chapter focused on the background of the study. In this chapter discussion will be more on what other researchers understand and discovered about the topic in discussion. It reviews the literature which deals mostly with the influence of practical work in learning and teaching Natural Sciences. International and South African articles will be reviewed with the aim of observing the trends and comparing the contexts. Focus is more on recent studies. Theoretical frameworks underpinning the study will also be discussed in this chapter.

2.2 Theoretical framework

According to Labaree (2013) the theoretical framework is the structure that can hold or support a theory of a research study. It introduces and describes the theory that explains the research problem under study exists. This study is underpinned firstly by the theory of constructivism because it deals with learning. Other theories such as Pedagogical Content Knowledge (PCK) also had an influence on the outcomes of this study.

2.2.1 Constructivism

The theory of constructivism is based on the observation and the scientific investigation of how people learn. The theory considers how people construct their own understanding and knowledge of the world, by their experiences and their reflection on those experiences (Beyer, 2009). When learners come across something new, they have to reflect and reconcile this with their previous knowledge and experience, sometimes changing what they believe, or disregarding the incoming new information as irrelevant. People are active constructors and creators of their knowledge by asking questions and exploring and assessing what they know.

Ijomah (2015) describes science as a special type of discipline with peculiar characteristics, the prominent among which is the approach (scientific method) through which knowledge is sought. Exercising practical work in science gives the real meaning to the above description.

According to Bhattacharjee (2015), constructivist teaching is based on the understanding that learning occurs when learners are actively involved in a process of construction of meaning and knowledge as opposed to passively accepting information. The learner must be involved in practical lesson, understand the experiences and discussion in the science class. She or he must use it to ‘construct meaning’. In traditional teaching and learning environments learners memorise what they are told my teachers rather than constructing their own meaning. Learners are actually young scientists trying to find out how the world works. The work of Miller (2004) relates that people often forget this. Scientists work on the boundary of human knowledge and their research is directed at the unknown. Children explore and find out precisely what people already know. Starting a lesson generally starts by determining the learner prior knowledge so that a teacher build on the existing knowledge. This basically involves connecting existing knowledge with new knowledge. This represents how learning at the school level takes place which is quite distinct from discovery or construction of ideas that are new and unknown.

Miller (2004) describes science learning as making what others already know your own. It is actually connecting ideas as one of the specific aim of natural science and technology state that the primary task of teaching is to construct a framework of knowledge for learners and to help them connect between the ideas and concepts in their minds. This is quite different from learners just knowing a lot of facts (CAPS 2011). According to Miller (2004) it is different from a cognitive perspective For example like solving a puzzle on the one side and on the other side having the solution explained to you by someone who already knows it. Constructivism encourages learners to constantly reflect on how an activity is helping them gain understanding. Through asking questions and employing new strategies, students in a constructivist classroom ideally become expert learners (Tseng et al, 2013). This gives them tools to continue learning and with a well-planned classroom environment. The students learn how to learn.

This might look like a spiral. Continuous reflection on their experiences allows learners to find their ideas gaining in power and complexity as they develop increasingly strong abilities to integrate new information. The teacher's main role becomes to encourage the learning and reflection processes. One example could be that groups of learners in a science class are discussing a problem in Natural

Sciences. Although the teacher knows the solution to the problem, she directs her attention on assisting learners rephrase their questions in useful ways. Each student is prompted to reflect on and to examine their existing knowledge. If one of the learners discovers a new understanding, she seizes upon it, and directs the learners that this might be a fruitful path for them to uncover. Learners are then directed to design and perform relevant tests. The students and teacher discuss what they have learned, and how their observations and testing helped (or did not help) to better understand the problem (Thirteen Ed Online, 2004).

Khalid and Azeem (2012) argue that constructivism does not dismiss the active role of the teacher or the value of their expert knowledge. It changes the teacher's involvement, so that teachers help students to construct knowledge rather than to reproduce a series of facts. A constructivist-oriented teacher provides tools such as problem-solving and inquiry-based learning activities with which students formulate and test their ideas, draw conclusions, and convey their understanding in a creative learning environment. The constructivist classroom transforms the learner from a passive sponge of information to an active and involved contributor to the learning process. Guided by the teacher, learners construct knowledge actively rather than just the ingestion of knowledge from the teacher or the textbook.

The theory of constructivism accesses and stimulates the learners' inner curiosity about the world and how things work. Learners do not necessarily reinvent the wheel but attempt to explain how it turns and how it functions. Learners become involved by using their existing knowledge and real-world experience and learn to hypothesize, test their theories, and ultimately draw conclusions from their results. It is important for the teachers to understand what constructivism is about, what it means for science teaching in the classroom. This can be done by observing examples at work, discussing their science teaching with others about it, and the attempting it the classroom.

Sjøberg (2007) warns that constructivism as a term should be used with caution because it is used in different fields with different meanings. However, he has noted that out of millions of internet search entries from constructivism most of them are on education and relative widely to mathematics science and technology. Carter (2009) sees Jerome Bruner as one of the most recognized proponent of constructivism.

Reading further about constructivism one would find that constructivism has different forms or branches. There is social constructivism, cognitive constructivism. With his stress on the social and collaborative nature of learning, Vygotsky is often considered to be the father of social constructivism, while Piaget is often classified as a father of personal (or cognitive) constructivism. Vygotsky (1978) believes that community places an important role in the process of making meaning.

Good (1993) and Solomon (1994) confirm that there are few forms of constructivism such as personal, radical, social, critical and contextual. Socio-cultural constructivism is the one used to support the study. This theoretical framework is relevant for the study of practical work because when teaching Natural Sciences using practical work a teacher allows a learner to construct their own knowledge by interacting with science equipment. In this type of approach teacher guide learners by probing them with questions instead of just feeding them information. Looking at how most researchers describe practical work one would recognize the suitability of the framework.

According to Abrahams and Millar (2008) practical work involve activities in which the learner change and see real objects and materials. The study by Stoffels (2005) considered practical work as teaching and learning approaches where learners are given enough hands-on opportunities to practice the processes of investigation. It involves any hands-on and minds-on practical learning opportunities where learners try and develop various cognitive process skills such as observation, ask questions, develop hypotheses, predicts, collects, records, analyses and interprets data. When doing acids, basis and neutrals, grade 7 learners have to investigate their properties themselves rather than a teacher explaining it to them. In fact, they will have to predict them first and test their predictions. However, Newton, Driver and Osborne (1999) see a tension between observations, experiments and interpretations. They do not believe that they are cornerstones for sciences as opposed to most people, they see them as activities constituting knowledge claims through argument.

2.2.2 Pedagogical Content Knowledge

The second theoretical framework underpinning the study is pedagogical content knowledge (PCK). Linder et al (2014) suggests the possibility of framing the study in terms of Shulman's Pedagogical Content Knowledge when interviewing the teachers about their teaching strategies. This justifies the use of Pedagogical Content Knowledge as the second theoretical framework to support the study. The framework concerns with representation of information, strategies to complicate or to simplify concepts. One should remember that learning does not only depend on a learner alone but also the way in which information has been imparted on the learner. That is why teaching strategies are timeously being modified. During interviews in the study teachers' questions are structured such that in their responses teachers evaluate and compare two teaching strategies, namely practical work and traditional teaching. The strategy of teaching used in the study is practical work. This teaching is done collaboratively in three schools where the researcher is co-teacher in all lessons conducted. In this kind of teaching there are more chances that learners would not understand a certain concept explained by one teacher will grasp it when explained by the other.

Education policy demands that teachers meet a high qualification standard with emphasis on demonstrating competency in science subject matter but under emphasizes the value of other areas of teacher knowledge, such as pedagogical content knowledge which is critical to the success of teaching of K-20 science. According to Gess-Newsome and Lederman (2001), Shulman (1987) emphasises that pedagogical content knowledge (PCK) is one of seven knowledge areas for teaching. These areas include knowledge of content, general teaching strategies, curriculum, learners, educational settings, and aims of education. Shulman (1987) sees PCK as a special combination of content and pedagogy that is uniquely constructed by teachers. This is a special form of a teacher's professional knowing and understanding. PCK represents the blending of pedagogy and content into a framework of how particular topics, issues and problems are adapted, organized and represented to the diverse interests and abilities of learners and presented for instruction.

PCK is generally known as the transformation of subject matter knowledge and general pedagogical knowledge. Some authors have the view that PCK is a separate category consisting of subject matter, pedagogical and educational context knowledge (Magnusson, Krajcik, Borko, 1999). Despite the lack of agreement, many researchers are of the view that the unique qualities of PCK are relevant in understanding science education and science teaching.

Education Policy such as the National Science Education Standards (1996) states that better science teaching could lead to increasing achievement for all students. However, science classes have remained virtually unchanged despite various interventions. Permutations of the phrase teachers teach as they were taught echo throughout the research literature on science classroom practices. Thus, after 20-plus years of reform efforts, what is often seen in science classrooms are the same teaching practices we experienced as learners. Traditional approaches are not necessarily bad, but are sometimes overused. No one teaching approach is any better than the next, but there are challenges when teachers rely on only one or two teaching methods. Successful science teachers are the one who draw from a wealth of pedagogical approaches. Understanding how to reflect upon the planning, selection, and implementation of science content and pedagogy that can provide meaningful learning for students is the core of pedagogical content knowledge.

Learner achievement has demonstrated improvement when teachers had a strong content background in coursework and teaching experience on the one side and pedagogical knowledge for example hands-on inquiry, training in classroom practices, and wait time, on the other. Neither a solid content nor a good pedagogical knowledge alone is sufficient to improve learner achievement drastically. It is the teacher's ability to transform his or her knowledge of the subject matter and pedagogical knowledge that is absolutely essential to student achievement. To change the way teachers teach science should involve new experiences that enable them to learn to teach in different ways that may include an array of pedagogical methods. These methods should that include inquiry, constructivism, 5E cycle, conceptual organizers, questioning, nature of science, cooperative learning, and authentic science laboratory investigations.

Van Driel, Verloop, and deVos (1998) found that the PCK of teachers could be improved by intensive short term, skills-oriented training sessions which could generate change in teachers as a result of developing pedagogical content knowledge (Clermont et al., 1993). In addition, through an empirical study the investigators found that there is value in having prospective teachers study subject matter from a teaching perspective. This and other studies (Lederman, & Chang, 1997; Smith, & Neale, 1989) have also demonstrated the value of PCK in especially science teaching. Teachers are required to observe, refine and practice teaching pedagogies to develop the skills required to deliver quality science teaching. The more teachers' pedagogical content knowledge improves (both in pedagogy and content), the more their abilities to influence learning increases (McREL, 2001).

Studies on the influence of teacher knowledge on learning outcomes are limited. The few studies found have concentrated on pedagogical content knowledge or content knowledge. Speer (2010) indicated that the following implications are emerging:

- Improved content knowledge of teachers leads to better student achievement Mathematics teachers
- Improved pedagogical content knowledge leads to better student achievement Mathematics Teachers
- PCK has more influence on student achievement than content knowledge;
- Only PCK seems to have an impact on the quality of Instruction
- Improved general pedagogical/psychological knowledge leads to better quality of instruction according to student perception (e.g. Higher cognitive activation, better instructional pacing, better student-teacher relationships)
- There was only one study on mathematics teachers PCK. Based on Hill, Rowan and Ball (2005), Baumert et al. (2010), and Voss, Kunter and Baumert (2011)

There has been a long history of debate and discussion around the relationship between teacher knowledge and quality instruction with a lack of empirical research testing this hypothesis or even connecting knowledge to student learning. The research reviewed show that while much research is still needed to fully support this relationship, studies thus far are beginning to show that teachers' general PK is relevant to understanding quality teaching as understood by its influence on student learning outcomes.

The PK base of teachers includes all the required cognitive knowledge for creating effective teaching and learning environments. According to Gottlieb (2015) most research use the distinction between declarative (knowing that) and procedural knowledge (knowing how) from cognitive psychology as a theoretical basis. This approach is important as it concentrates on understanding how knowledge is related to behaviour, or in other words, the quality of teaching performance. The study on teacher knowledge (Shulman, 1987) categorised teacher knowledge into 7 categories, among which were the concepts of:

- General PK (strategies and principles of classroom management and organization that are cross-curricular) and
- PCK (Integration of the content knowledge of a specific subject and the pedagogical knowledge for teaching that particular subject).

This study was regarded as the most fundamental element of teachers' knowledge and has been studied widely since. In contrast, general pedagogical knowledge has not been the object of many research studies even though several studies indicate that it is essential for developing quality teachers. Some models of general PK combine pedagogical and psychological aspects, whereas others don't make psychological aspects explicit. Psychological components account for the fact that learning occurs in a social context and learning success depends on the general cognitive and affective characteristics of individual students.

According to Guerriero (2014) understanding the knowledge of us as learning specialists involves understanding how this knowledge functions in the teaching-learning process. More specifically, how teachers apply their knowledge in making decisions. For example, these include teacher knowledge about lesson design or making on-your-feet judgements in the classroom. Some argue that decision-making is actually a basic teaching skill: – decisions are made regularly by teachers while processing cognitively complex information about the learner in order to decide alternatives for increasing their understanding.

Studies on different models that describe teachers' decision-making point to factors influencing teachers' decisions. These factors include antecedent conditions such as students, the nature of the instructional task, the classroom, and the school environment, which combine with teachers' characteristics and cognitive processes to impact the pedagogical decision made.

2.3 The role of practical work

Practical work has remained a core component of school science education despite the debates and discussion around its value in the science classroom. To this end the practical work component of an academic subject is an important aspect that separates science from many other learning areas in secondary schools. Despite the fact that the use of practical work in England is recognised as important (Science Community Representing Education (SCORE), 2008), it, according to some studies (Bennett, 2005; Woolnough, 1998), remains rather on the side-lines in terms of the limited quantity and time devoted to it compared to some other countries. However, strong science teacher is adamant that practical work represents what teaching and learning science is all about (Woodley, 2009). Studies by Skamp (2011) and Hartley (2014) reveal that the use of p+ractical work creates a vibrant learning environment for teaching and learning of science which could improve learners' results. However, there is an open discussion surrounding the affective and effective value practical work has on learners and their learning (Abrahams, 2009; Abrahams & Millar, 2008; Hodson, 1991; Millar, 1998).

It appears that in English schools that it is difficult to speak of science education without considering practical work. According to Abrahams and Millar (2008) many teachers view practical work as central to the appeal and effectiveness of science education. Many refer to the old adage by Confucius, namely "I hear and I forget, I see and I remember, I do and I understand". In contrast Driver (1983) explained that doing practical work does not always lead to progression in learning science. Practical work does not always produce the results or the phenomena desired by the teacher. This situation has the potential to either confuse or disengage students as they may begin to think either that the theory is incorrect or that the practical investigation is providing them with incorrect or contradictory results to those predicted by the scientific theory. This scenario shapes the adage, "I do and I am even more confused" (Driver, 1983, p. 9). Yet despite the debates about the affective and effective value of practical work (primarily due to the concern over learner uptake of science post compulsion), it continues to be integrated into science lessons. Wickman (2002) has even suggested that teachers find using practical work to be a method of behaviour management.

According to Hartley (2014), the role of practical work in South Africa is underestimated, especially by the teachers from previously disadvantaged schools and primary schools. This becomes evident during workshops for science teachers. They complain about having too much paperwork and that practical work will be too time-consuming. The purpose of this study is also to prove or disprove most of these complaints. There is a wide range of good practical work in science taking place across the UK but there are indications that the situation could be improved by extending good practice and focusing on the quality, rather than just the quantity of practical work (SCORE, 2008). Concurring with SCORE good quality practical work will yield positive long term influence in the teaching of Natural Sciences.

Practical work takes on many definitions and explanations. This means that it can impact differently on learners. In the science education literature, it is generally understood that understanding of science concepts cannot simply be transmitted directly from teacher to learner but that requires the learner to get involved in their own learning and actively make sense of new information (Hobden 2005). Motlhabane and Dichaba (2013) showed that teachers can acquire valuable skills through role-play. According to the above study the learners will want to imitate the teacher after seeing him or her performing practical work. Many empiricists believe that the true knowledge is achieved by senses. Considering some of the definitions of practical work one would know that learners will interact with the apparatus using senses and since all human senses are connected to the brain, it makes it easier for learners to remember what they did. In this study learners will employ their senses to determine whether substances are acids, bases or neutrals. Through practical work knowledge can be embedded in all the senses involved during the lesson.

Practical work should also help in bringing concepts' definitions like what is called operational definitions as opposed to constitutive definitions. Operational definitions serve as "stand-ins" for mental processes which cannot be observed directly. An operational definition is a more practical and applied definition that makes it possible to precisely define the class and identify individual with intellectual disability (ID). In distinction a constitutive definition is more theoretical definition that is used to define the theoretical construct behind ID (Luckasson & Schalock, 2013). On acids, bases and neutrals, acids could be defined as that substance that tastes sour and changes a blue litmus paper red. These definitions can only be formulated in the laboratories or through practical work, done by learners themselves. Such definitions should be accepted at primary schools then developed and high schools. As part of practical assessment (investigation in acids, bases and neutrals) there should be a question that say: "Define acids in your own words from how you handled them or tests done".

The Natural Sciences section of the South African Curriculum and Assessment Policy Statements (CAPS) placed a strong emphasis on 'doing science', as opposed to learning about the facts and theories of science. The relevant outcome, the first of three, is stated as *learners should be able to complete investigations, analyse problems and use practical processes and skills in designing and evaluating solutions* (Department of Education, 2011).

2.4 The nature of practical work

According to Kirschner (1992) the discovery approach to practical work was criticised for providing a false view of science, namely the idea of reaching theoretical conclusions solely from observations, known as the inductive process. This discovery approach was accused of becoming overly concentrated on the doing of practical work. Instead of understanding scientific concepts it made doing science appear as a method, a set of rules, that could be applied to determine any scientific theory (Wellington, 2002). According to Jenkins (1979) the concepts of science were becoming overwhelmingly distant from pure common sense. It became very challenging to convince people that learners must assume the position of discoverer. To retain and maintain this position, science owed its achievements to a method which was considered a game of which the rules could be learnt and applied.

There were many challenges for science teachers when applying the approach in their science lessons. It became very difficult for students to observe what was expected in the lesson. These challenges could be ascribed to false assumptions in the fundamentals underlying the approach rather than the teacher's capability amongst other reasons (Millar, 1989). According to Wellington (2002) whatever extent of the criticisms there were still a number of experiments with new items of apparatus which became customary in today's science lessons. Many researchers indicate that although some recipe method experiments have become part of current teaching, there was little evidence or acknowledgement that by being involved through leads to students' understanding or that involvement in science increased with this approach (Millar, 2004; The Dainton Report, 2006; Woodley, 2009).

There was greater criticism levelled at the process approach than the discovery approach (Wellington, 2002; Millar, 1991). According to Millar (1991) the process model involved the understanding that science consists of a set method of discrete processes whereby skills and processes could be separate from the natural theoretical aspects of science. The process approach attempted to provide science for all abilities. One view was that if learners were of lesser ability, learning scientific skills that were transferable would be better suited to them, over any scientific content (Wellington, 2002). This approach to practical work in the science class provided an uneven view of what was meant to study science. Millar and Driver (1987) explained that the aim should be the development of an in-depth understanding of science concepts and purposes of science. Science, they argued, is characterised by its concepts and purposes, not by its methods. Gott and Mashiter (1994) noted that while acknowledging that the methods of science are important; the methods are those of induction and operate within a concept acquisition framework. In addition, they suggested that this is a possible reason for the limitation of practical work in influencing students' attitudes in studying science. Chalmers (2006) indicated that the model of science that is constructed within a process approach is based on naive inductivism that many considered as unsound (Leach, Millar, Ryder & Séré, 2000; Segal, 1997). These authors suggested that the process approach was teaching learners skills learnt naturally from an early age (Hodson & Bencze, 1998; Millar, 1989; Wellington, 1989), such as observing that a plant grows if it is provided with the right amount of nutrients or the classification of objects according to certain properties.

Wellington (2002) refers the final approach as regarding practical work by order. This relates to the situation since the National Curriculum was introduced in 1988. The curriculum for Education and Science stated five components with practical work being included in the form of investigations. Learners were being assessed on scientific facts which begged the questions what the learners were actually investigating and what was being examined. SCORE (2008) explained that teachers found the science curriculum content as the major inhibitor of the extent to which practical work was conducted. In addition, it was observed that for some learners this concentration on content led them to be disinterested with learning about science (House of Commons, 2002; Kind & Taber, 2005)

2.5 The aims and purposes of practical work

There have been many studies that produced categories of reasons for conducting practical work within science education. Shulman and Tamir (1973) and Anderson (1976), both proposed aims of practical work. The following were indicated:

According to Shulman and Tamir (1973):

(1) Arousing and maintaining attitude, open-mindedness, interest, curiosity and satisfaction in science

(2) Developing creative thought and problem-solving skills;

(3) Promoting areas of scientific thought and the scientific method (e.g., hypotheses and assumptions);

(4) Developing conceptual understanding and intellectual ability; and

(5) Developing practical abilities (e.g., design and execute investigations, observe, record data, and analyse and interpret results).

Anderson (1976) highlighted:

(1) Fostering knowledge of the human enterprise of science to enhance student intellectual and aesthetic understanding;

(2) Fostering science inquiry skills to transfer to other spheres of problem solving;

(3) Helping learners appreciate and in part emulate the role of the scientist; and

(4) Helping the learner grow both in appreciation of the orderliness of scientific knowledge and also in understanding the tentative nature of scientific theories and models.

Hofstein and Lunetta (1982) indicated that the above purposes were the same as the purposes for science and that specific reasons for practical work were needed. This was especially required at a time when there had been a shift from student-led work. According to Gott & Duggan (1995) this provided less experience and time in the science laboratory, primarily due to the need to meet examination requirements. Several studies emphasised that often the learners and the teacher concentrated on details of technical and manipulative importance that consume most of their time and energy. Such details seriously limit the time they can spend on meaningful inquiry (Hofstein & Lunetta, 2004).

The motivational aspect of practical work for learners was considered far too restrictive and favoured because the alternatives were presented in a negative way by teachers to learners (Woolnough and Allsop, 1985). Swain, Monk, and Johnson (2000) emphasised that this approach of using practical work as a way of behaviour control has been used by UK teachers as a means of dealing with mixed achieving classes. In response Swain et al. (2000) suggested three aims as reasons for teachers doing practical work. The aims included, (1) to reward pupils for good behaviour, (2) to allow students to work at their own pace, and (3) to add variety to classroom activities.

The study by Hodson (1990) revealed five aims for practical work taken from teachers' responses. These are:

1. Motivating, by stimulating interest and enjoyment.
2. Teaching laboratory skills.
3. Enhancing the learning of scientific knowledge.
4. Giving insight into scientific method, and develop expertise in using it.
5. Developing certain 'scientific attitudes', such as open-mindedness, objectivity and willingness to suspend judgement

However, Hodson (1990), found that theoretical arguments and research evidence reinforced the view that practical work in school science is largely unproductive and patently unable to justify the often extravagant claims made for it. Clackson and Wright (1992) drew similar conclusions. They suggested that there might be an argument for considering practical work as a subject in its own right. Their reason was that the acquisition of skills was generic and not focussed within science education. As SCORE (2008) puts it, the challenge with understanding the realistic purpose of practical work within science education is still an issue. This situation may potentially lead to a variety of approaches in conducting practical work in schools that could influence the learning outcomes for the students (Millar, 1998).

2.6 The impact of practical work on students

Scientists and science educators insist that practical work must play a central role in learning science, but the reasons for this centrality are unclear. This dilemma is rooted in the vagueness of the questions asked about the role of practical work. According to Watson (2000) asking if practical work is effective for learning is like asking whether children learn by reading. The solution is found in the nature and contents of the practical activities and the aims which they are trying to achieve.

According to a NESTA (2005) survey, 99% of the sample of science teachers believed that enquiry learning influence student performance and attainment. The views about the role of practical work in science education have been challenged. According to Donnelly et al. (1996) some science educators argue that practical work might help students understand how scientists work, while others indicate that a process-based approach (that is, an approach that focused on experimental skills) would lead to improved understanding of science concepts.

White and Gunstone's (1992) provided evidence of effective practice in the use of practical work. Their study indicates that students must manipulate ideas as well as materials in the school laboratory. According to Lunetta et al. (2007) a number of researchers emphasised that students need to understand something about the nature of science if they are to appreciate the limits and value of practical activities (Wolpert, 1992; Matthews, 1994; Lunetta, 1998; Abd-El-Khalick and Lederman, 2000; Duschl, 2000). The teacher plays a critical role in helping students compare their findings with those of their peers and with the wider science community (Driver, 1995).

A study by Freedman (1997) investigated the impact of a hands-on science programme on attainment and attitudes reported that students [aged 14-15] who had regular laboratory instruction. These learners (1) scored significantly higher ($p < .01$) on the objective examination of achievement in science knowledge than those who had no laboratory experiences; (2) exhibited a moderate, positive correlation ($r = .406$) between their attitude toward science and their achievement; and (3) scored significantly higher ($p < .01$) on achievement in science knowledge after these scores were adjusted on the attitude toward science covariable. (p. 343).

Researchers reported that practical work can increase students' sense of ownership of their learning and can increase their motivation (Johnstone and Al-Shuaili, 2001). In a comparison study by Thompson and Soyibo (2001), the authors reported positive impacts of a combination of practical work, lectures, discussions and teacher demonstrations on Jamaican 10th grade [age 15-16] students' attitudes to the understanding of electrolysis in chemistry. A number of researchers (Brown et al., 1989; Roth, 1995; Williams and Hmelo, 1998; Wenger, 1998; Polman, 1999) indicates that learning needs to be contextualised to be effective. According to Lunetta et al. (2007) learners construct knowledge by solving genuine, meaningful problems. These results suggest that practical activities that have no context and are set up to practise practical skills or for purposes of assessment may generate lower quality achievement compared to tasks which appear to students to have a purpose connected to their daily lives.

Working with 5th grade (UK Year 6) learners in the US describes a process of designing, implementing, and evaluating problem- and project-based curricula. Barron et al. (1998) describe four design principles that lead to positive effects on student learning namely (1) defining learning-appropriate goals that lead to deep understanding; (2) providing scaffolds such as 'embedded teaching', 'teaching tools', sets of 'contrasting cases', and beginning with problem-based learning activities before initiating projects; (3) ensuring multiple opportunities for formative self-assessment and revision; and (4) developing social structures that promote participation and a sense of agency. The authors point out that a major hurdle in implementing project-based curricula is that they require simultaneous changes in curriculum, instruction, and assessment practices. These changes are often foreign to the students as well as the teachers.

A number of researchers (Jakeways, 1986; Woolnough, 1994) provide some evidence that experience of conducting extended practical projects can provide students with insights into scientific practice which could increase interest in science and motivation to continue its study. Such examples of the successful use of extended projects are, however, mainly at upper secondary school level or above, where students are to some extent self-selected, teachers have (in general) better subject knowledge, and group sizes are smaller.

2.7 The use of Information Technology in practical work

Information technology is constantly changing as new hardware and software products are introduced. According to Lunetta et al. (2007) science education studies have not been helpful to distinguish between and to join important ends (as learning outcomes are sought) and the means to the ends (for example teaching resources and strategies including investigative activities in the laboratory). Changes in technologies since the early eighties offered new resources for teaching and learning, but not enough attention has been directed to determine how these technologies can add value to experiences in the school laboratory. (p. 396)

According to Barton (1998) and Lunetta (1998) continuous advances in technology have provided a wide array of new opportunities for innovative science education. Braund and Reiss (2006) indicate that these opportunities include simulations, the use of sensors, and the internet. Computer-based simulations may also help to reduce the 'noise' of the laboratory bench and focus attention on important aspects of experimental planning and data interpretation (Millar, 1999, 2004). He also notes that computer-based tools (for example, Bell and Linn, 2000; Sandoval, 2003) could assist to involve learners more actively in thinking about issues of theory choice. Computers can be used to assist long-term investigations, for example in data-logging (Dori et al., 2004). Computers can assist in the visualizing data.

Recent studies indicated that learners properly use inquiry empowering technologies to gather and to analyze data, students have more time to observe, reflect, and construct conceptual knowledge that underlies their laboratory experiences. The graphics also offer visualization which enhances learners' experiences with authentic activities with promoting deeper conceptual understanding (Edelson, 2001). When learners have the time and when the activity is valued by the learners can examine functional relationships and the effects of modifying variables; they can also make and test predictions and explanations. New technologies that offer display of data as it is gathered offer opportunities through which students may be helped to understand systemic functional relationships and more holistic relationships among variables. Using appropriate technological tools could allow learners to conduct, interpret, and report more complete, accurate, and interesting investigations. These tools can provide media that support communication, student – student collaboration, the development of a community of inquirers in the laboratory-classroom and beyond, and the development of argumentation skills (Zembal-Saul et al., 2002).

According to Lunetta et al. (2007) evidence now documents that using appropriate technologies in the school laboratory can enhance learning. An initial cautionary note must be added because evidence also documents that inappropriate application of even simple technology tools interfered with meaningful science learning (Hofstein and Lunetta, 2004). When a device is introduced before learners have made sense of the underlying science concepts, there is evidence that tool may serve as a "black-box" that interferes with learners' perceptions of what is happening and hinder their understanding of important scientific ideas.

The application of internet-based courses is increasingly being seen as a potential resource for science education. According to Linn (2000) the internet provides a chaotic, confusing, persuasive and informative area of scientific information. The internet is useful in that it provides guidance and lesson materials to encourage effective and engaging practical work in the classroom and to ensure that teachers link this to learning objectives and development of subject knowledge. It encourages practical work to be used with other learning tools. Zacharia (2003) reports on a study designed to investigate the effect of interactive computer-based simulations, the use of laboratory inquiry-based experiments and the use of combinations of both. The study found that beliefs affect attitudes and these attitudes then affect intentions, and showed that science teachers' attitudes toward science and the use of the teaching approaches were highly positive. A blended approach to laboratory work and simulations was found to be effective with Finnish elementary learners.

2.8 Improving the quality of practical work

Learners need to think as well as act. Duckworth (1990) had noted that effective tasks are those where students are not only hands on but also minds on (Millar, 2004). Improving the quality of practical activities requires first that teachers become aware that making links between the domain of objects and observables and the domain of ideas is demanding, and then assisting teachers to design practical tasks including tasks which scaffold learners' attempts to make these links. This would require that teachers scrutinise carefully the objectives of practical tasks learners undertake and of the cognitive challenge for their learners. The beginning for improving practical work is to assist teachers to become much clearer than many are at present about the learning objectives of the practical tasks they use (Millar, 2004).

Many studies over the years have indicated that practical work has the potential to contribute to meaningful learning in science. Specific aim one of the Natural Sciences learning area CAPS can only be achieved if practical work, broadly defined, is performed on a regular basis. Learners can gain an understanding from lower level practices of how existing scientific knowledge is confirmed, while the higher levels of practical work can help learners experience how new knowledge claims can be generated and substantiated. If practical work will be conducted as well as the types of practical work depends, not only on intentions of policy documents, but on the decisions of science teachers. According to Millar (2004) it appears from the findings that teachers' decisions to use practical work depend on various factors. The most prominent factor appears to be the teachers' perceptions of their learners. It is likely that teachers who perceive their learners to be motivated and non-disruptive will engage learners in higher-level types of practical work. To a lesser extent is the attitude of teachers in the school towards innovation. In a school where innovation is generally supported, science teachers engage in higher levels of practical work. A well-functioning school also appears to be an important factor. Where learners have ta strong influence in motivating teachers to provide higher level types of practical work, creative ways are sought to capitalize on this finding.

One professional development strategy that has the potential to promote this upward spiral is to introduce innovative practices directly into the classroom. Instead of these practices being introduced to teachers in a venue that is removed from the classroom, they could be taught to learners with the teachers as participant observers. The Japanese practice of lesson study does in fact take just this approach (Kita, Ndlalane, Nishioka, Ono & Paulsen, 2007). Teachers, with or without outside support, plan jointly on how to introduce a particular innovation into a classroom. This new lesson is then taught in a real classroom by one teacher while the others act as observers. Finally, the lesson as practiced in the classroom is analyzed, and improvements suggested. If the learners are excited and challenged by this jointly planned lesson, then all participating teachers are likely to become more motivated.

The MSSI project is, in fact, attempting to introduce this technique into Mpumalanga secondary schools. The other finding that has important implications is that the doing of practical work is not significantly dependent on whether teachers have physical resources (e.g. laboratories, science apparatus or portable laboratory stations). It seems that those who are motivated to do practical work will find ways to do so even in the most poorly resourced of schools. Conversely those who are not motivated will not do practical work even when they have access to the best of resources. There appears to be no link between the provision of resources and the capacity of teachers. Schools are provided with resources simultaneously whether they want them, and are ready for them, or not. For example, all schools in Mpumalanga were recently supplied with micro-chemistry kits – even junior secondary schools, which end with grade 9, were supplied with these kits although they are designed for the FET phase (grades10-12). The boxes of these kits are still found unpacked. How much more effective it might have been if these kits had been supplied to teachers as part of their professional development program, and then only when the teacher concerned indicated that he or she was ready, willing and able to use these resources. This implication is, in effect, simply a restatement of policy suggestion made in the Department of Education (2000) document calling for schools to be equipped on the basis of the 'need to have, able to use principle.

2.9 Conclusion

This chapter reviews literature on practical work looking at how other researchers understand and experience this part of science teaching. The chapter also reviewed theoretical frameworks underpinning the study. The next chapter will present the methodology.

Chapter 3

Methodology

3.1 Introduction

The purpose of the study is to investigate the influence of practical work in teaching and learning Natural Sciences in Grade 7. The research methodology used in this study is aimed at extracting useful information from both teachers and learners. The chapter outlines research methodology used in the study. This main purpose was addressed by seeking answers to the following specific research question:

How does practical work influence teaching and learning of acids, bases and neutrals in Natural Sciences?

In order to address the main research question the following research sub-questions were answered:

- What was learners understanding of acids, bases and neutrals before the practical-based lessons?
- How were the practical-based lessons implemented?
- What were learners' understanding of acids, bases and neutrals after the practical-based lessons?
- What were learners' perceptions of the practical-based lessons?
- What were teachers' perceptions of the practical-based lessons?

This chapter aims mainly to discuss research design of the study, study sample, procedure used to design instruments, data collection and data analysis techniques used to get finding for the research.

3.2 Research Objectives

The aim of this study is to establish the influence of practical work in teaching and learning of acids, bases and neutrals in grade seven Natural Sciences. The study was done with the purpose of answering a research question using different research instruments. Although the focus is on the influence practical work has on learning and teaching, influence on attitudes could not be avoided. Practical work also impacts on attitude learners have on a lesson. To know if the attitudes are negative or positive needs a different research with suitable instruments.

3.3 Research Design

There are many ways to conduct research. Each of these ways is used in various professional fields, including psychology, sociology, social work, medicine, nursing, education and so on. As the field of education often uses action research, it is also used in this study. Action research is an interactive method of collecting information that's used to explore topics of teaching, curriculum development and student behavior in the classroom (McCallister, 2003).

Research methodology is a systematic, purposeful and planned process followed by the researcher to collect and analyse data. According to Myers (2009) research methodology is the way of inquiry which links the fundamental postulations, the research design and collection data. This study used a mixed methods design to collect data. Johnson and Christensen (2004) describe mixed methods research as the category of research studies whereby a researcher combines quantitative and qualitative research approaches into a single research study. Creswell (1998) sees qualitative research as the research process designed according to a clear methodological tradition of research, whereby researchers build up a complex, holistic framework by analysing narratives and observations, conducting the research work in the habitat. The data was obtained through the use qualitative instruments which entail observation and participant interviews and quantitative instruments that entails pre-test and post-test. Instruments used were pre-test (Appendix A), intervention was videotaped (Appendix B), observation (Appendix C), post-test (Appendix D) and interviews. These instruments are fully discussed under instruments below. The information was gathered with the intention of validating the findings.

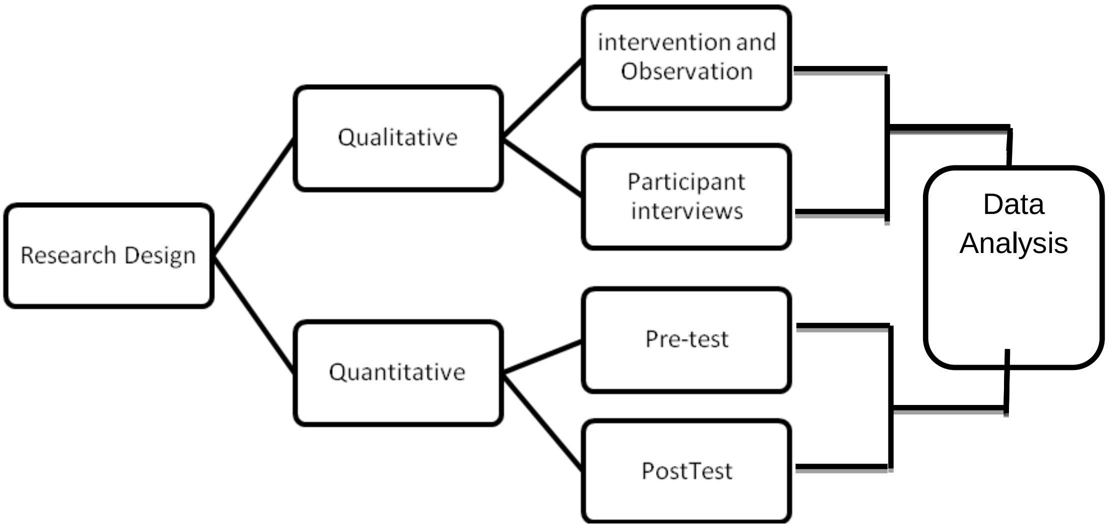

Figure 1: Research design

Figure 1 above illustrates how the research design was used including the instruments. The qualitative approach applied in the study includes interviews of both teachers and learners and observation of the intervention. This approach was chosen because in the approach a researcher is ideally an objective observer who neither participates nor influences what is being studied. On the other hand, quantitative approach involves pre-test and post-test scores. The advantage of using this approach is that it allows the researcher to be flexible; the researcher can change the strategies during the research.

3.4 Research setting

The study was conducted in primary schools that are situated in KwaNobuhle, one of the disadvantaged township in Nelson Mandela Bay Municipality. All of the primary schools in the township do not have science laboratories. Parents who can afford, send their children to affluent schools with facilities that can contribute to their children receiving 'good' education. In this study the researcher focussed in the primary schools, in the disadvantaged areas. Building strong foundation strengthens the structure. The study further focussed on learners in Grade 7 doing Natural Sciences. In South African curriculum intermediate phase learners (Grade 4 – 6) take Natural Sciences and Technology as one subject. It is only in senior phase (Grade 7 – 9) where they take pure Natural Sciences. Grade 7 is where transition starts, when learners start to work in science only as part of Natural Science. These learners also have a language barrier which impacts on results, but this aspect is not going to be discussed in the study.

3.5 Study population and sample

According to Borg and Gall (1989) sampling means selecting a given number of subjects from a defined population as representative of that population. In this study three primary schools out of twelve primary schools were selected in the KwaNobuhle township for the sample. This means that the sample is 25% of the population. The advantage of this technique is to ensure balance of group sizes when multiple groups are to be selected. Purposeful sampling was used to choose schools for the research because schools in close proximity to the researcher were selected. In this study participants included in the sample were selected to meet certain criteria.

- Three primary schools in close proximity to the researcher were selected. A school had to have at least one grade seven class.
- One teacher per school was sampled on the bases that s/he teaches Natural Sciences in grade 7. The teacher had to be teaching Natural Sciences at the sampled school. In total three teachers were sampled.
- Two of the three sampled school had one grade seven class each. This means that the whole population was sampled. One school had seven grade seven classes and Natural Sciences teacher of the school just identified one class of his choice. Table 2 below summarizes how sampling was done.

Table 2: Sample Table

Participants	Sample	Technique	Criteria
Schools	3	Purposive	Schools in close proximity
Teachers	3	Purposive	Natural Sciences teacher Teach in the sampled schools
Class	3 classes, 1 class per school	Random	Grade 7 learners
Learners	9 learners, 3 per class	Random	Learners per class for interviews

3.6 Pilot study

A pilot study was conducted prior to embarking on the full scale research (Kumar, 2005). This was done to test the questionnaire's relevance, suitability and accuracy of questions sample and language appropriateness. Depending on the findings of the factors analysis, researchers might go to the literature and develop items to pilot or determine the instrument's structures and assess its reliability analysis, (Warner, 2013). Pilot testing allows a researcher the chance to correct errors and to redesign problematic parts before the survey is mass produced and used. In concurring with this Welman (2009) adds that the purpose of piloting was to identify unclear or ambiguously formulated items.

In this study the researcher piloted the instruments with a non-participating school. The opportunity arose when the local Science and Technology Centre facilitators coincidentally requested to teach acids, bases and neutrals to the school's grade 7 learners. After piloting the instruments, they were validated by an expert in the field.

3.7 Data Collection Plan

The data collection plan is summarised in Table 3.

3.7.1 Learners understanding of before the practical-based lessons

Pre-test is the assessment that is done before the practical–based lessons were done to the sample. The study was conducted after the teachers completed the section of acids, bases and neutrals with the learners. All three teachers indicated that they did the lessons theoretically. They gave various reasons for not being able to do the lesson practically. The pre-test was aimed at establishing what the learners know thus far and what they do not know. It was also to determine if learners could remember vividly what colour changes take place on indicators with acids bases and neutrals although the lessons were done theoretical only. For this study a test on acids bases and neutrals was set following the assessment policy guide lines of the Department of Basic Education in South Africa. The scores achieved by learners and the number of learners with high scores were important to determine if learners could get good scores even without a practical. In writing this test, learners relied only on the knowledge they got from home or the theoretical lesson received prior to the intervention.

3.7.2 Implementation of the practical-based lessons

After the pre-test, intervention was done in the form of collaborative teaching. The intervention was intended to display an alternative way of learning and teaching to both learners and teachers respectively. This gave them an opportunity to compare this style of teaching to the traditional one.

Table 3: Data collection Plan

Research Question	School A Methodology	School B Methodology	School C Methodology	Instrument	Respondents	Analysis
What was learners understanding of acids, bases and neutrals before the practical-based lessons?	Pre-test	Pre-test	Pre-test	Question Paper	Learners	Excel
How were the practical-based lessons implemented?	Intervention	Intervention	Intervention	Lesson Plan	Learners	Excel
	Observation and video-taping	Observation	Observation	Observation schedule	Teachers	Coding
What were learners' understanding of acids, bases and neutrals after the practical-based lessons?	Post test	Post test	Post test	Question paper	Learners	Excel
What were learners' perceptions of practical-based lessons?	Interviews	Interviews	Individual Interviews	Interview schedule	Learners	Coding
What were teachers' perceptions after practical-based lessons?	Interviews	Interviews	Interviews	Interview schedule	Teachers	Coding

The researcher arranged with the facilitators of the Nelson Mandela Bay Science and Technology Centre as it was in their programme to assist schools with practical work. Teaching was therefore done by the school grade 7 NS teacher, the three facilitators and the researcher (presenters). Three lessons were observed. The observations were video-taped and the observation schedule was used as the instrument to collect data.

While presenters took turns to conduct the practical work others were assistants and monitored the group work. In the introduction lab assistants helped groups to set the apparatus in their tables. The lab assistants also supervised handling of the apparatus and chemicals. They would only assist learners when no one in a group knows what to do.

3.7.3 Learners' understanding after the practical-based lessons

A test similar to the pre-test was given to the sample. It must be noted that this was not a practical test although it is written after a practical lesson. This test was done to evaluate the effect or influence the intervention made in the understanding of concepts in acid, bases and neutrals. Like the pre-test, post-test was meant to establish how well they could remember changes in the indicators with acids, bases and neutrals. Questions were inclusive of all three cognitive levels of assessment namely lower order, medium order and higher order questions. Learners had to be able to recall three domestic and industrial acids and bases. As the learners tested acids and bases using indicators on their own, expectations were for them what colour changes would occur. All classes were given the same test (Appendix D) so as to ensure fairness and ridding of bias.

3.7.4 Learners' perceptions of the practical-based lessons

After the practical-based lesson three learners from each school were interview. These interviews aimed at getting their perception of the lesson and compared it to traditional lesson that they are used to. Individual interviews were conducted they were told not to disclose what was asked to the ones who have not been asked yet. Learners gladly obliged.

3.7.5 Teachers' perceptions of the practical-based lessons

A teacher that was part of the lesson was interviewed after all three learners were interviewed. This was just for convenience purposes. Teachers had to reflect on their experience of both traditional teaching and practical based lessons.

3.8 Development of research instruments

Research instruments are tools that can be used to extract relevant information from the sample. Instruments have to be designed such that they align with the research questions. The development of each instrument is discussed below. Five instrument were used, each instrument informed by the research question.

1. Question paper (Pre-test and post-test)
2. Observation schedule
3. Interview schedule for teachers
4. Interview schedule for learners

3.8.1 Tests

Learners in all three schools sampled were given the same pre-test which was meant to establish their prior knowledge about acids and bases.

3.8.2 Observation schedule

Observation is a process that gives a researcher data that is not easy to be tailored by the respondents. Marshall and Rossman (1989) describe observation as "the systematic description of events, behaviours, and artefact in the social setting chosen for the study" (p79). Kawulich and Barbara (2005) defines participant observation as the process enabling researchers to learn about the activities of the people under study in the natural setting through observing and participating in that activities. Participant observation is a qualitative method that seeks to help researchers pick up the perspectives held by the population under study. This, the researcher can achieve through observation alone or both observation and by observing and participating, to varying degrees. Marshall et al., (1989) define observation as the logical portrayal of events, behaviours, and artefacts in the social setting chosen for study. In the intervention classes the researcher took the observing and participating status. Depending on what the researcher aims to achieve different roles can be played in observation. One can either be participating observer, non-participating observer of changing observational roles observer. In this study the observations were used for four purposes:

1. to investigate learners' active involvement in lesson,
2. learner interaction with the apparatus,

3. use of learners' experiences by the teacher and

4. whether higher order learning tasks are available.

5. demonstrate the power of collaborative teaching.

Table 4: Advantages and disadvantages of Conducting Observational research

Advantages	Disadvantage
1. Access to situations and people where questionnaires and interviews are impossible or are inappropriate to use. 2. Access to people in real life situations. 3. Good for explaining meaning and context. 4. Can be strong on validity and in-depth understanding.	1 Can be viewed as too subjective. 2 Time consuming. 3 Depends on the role of researcher. 4 Overt: may affect the situation and thus validate findings 5 Covert: ethical principles contravened

Observation schedule had to measure learner activities taking place during practical as opposed to traditional learning and teaching.

The activities included learner:

- interacting with other learner/s
- learner/s interacting with the teacher/s
- teacher/s interacting with leaner/s

This schedule was designed to enable the researcher to observe these interactions. After each practical lesson the researcher watched the video clip and completed the observation schedule.

3.8.3 Interview schedule

At the end of the lessons the schools Natural Sciences teacher and three learners were interviewed using an interview schedule (Appendix E). According to Gill et al., (2008) when designing an interview schedule it is imperative to ask questions that are likely to yield as much information about the study phenomenon as possible and also be able to address the aims and objectives of the research.

An interviewer can follow up ideas, probe responses and investigate motives and feelings that any other instrument cannot do. The way a response is made can provide information that a written word would conceal, and if conducted by a skilful interviewer it can be most rewarding (Borg and Gall 1989: 415). The study comprised of semi-structured interviews in which open-ended questions were used. Both teachers and learners were interviewed separately. The aim was to get responses that are freely expressed without any fear or favour.

(i) Teacher-interviews

After every practical work a teacher teaching the class was interviewed and audio recorded. The interviews were intended to establish whether the teachers are normally doing practical work. How do they compare practical work to their normal teaching strategy? Although the research was not about attitudes, teachers should be able note the changes in learner attitude and learner involvement in the lesson. So the interviews were designed to reveal such information.

(ii) Learner –interviews

Three learners from each school were also interviewed. This was the way of triangulating the data from the teachers and observations. Learners were interviewed individually to allow learners to express themselves freely. These learners were randomly selected but they were willing to take part in interviews. In these interviews the researcher was able to get the understanding of how learners feel about being taught in acids and bases using practical work. As learners are isiXhosa speaking learners, they were asked to use language they are comfortable to use. Indeed, some learners spoke in isiXhosa. Interviews were audio recorded so that they could be replayed during the data analysis.

3.9 Data Analysis

Methods used to analyse data from tests, observations and interviews will be discussed. Unlike what Streubert and Carpenter (1999) believe, that in qualitative research data analysis starts immediately, the data collection process began in this research with the pre–test which is quantitative instrument. As in all research studies the data was organized and analysed. The strategy used to analyse date was such that it does not compromise its depth and richness. After the test was marked it was analysed so as to establish which questions most leaners could not answer. Also, from the data the researcher could determine the percentage of learners that have better understanding of concepts in acids, basis and neutrals. Excel was used to analyse pre-test scores. These results were kept to be used as reference when analysing post-test. The data analysis had to reveal the trends in respect of understanding acids, bases and neutrals of the learners before, during and after the interventions. One might want to know why there was no control group in the sample so as to be able to compare. The response to the question is that the study is a case study analysing the impact of practical work not the effectiveness of practical work. While the intervention was video-taped the observational field notes were done to add the appropriate non-audible actions, such as gestures and actions.

All the audio taped interviews were played repeatedly and transcribed. This is because the respondents were allowed to respond in the language of their choice and some responded in isiXhosa. DiCiccoBloom and Crabtree (2006) sees transcribing as difficult noting that it is not easy to capture "the spoken word in text form because of sentence structure, use of quotations, omissions and mistaking words or phrases for others". The transcriptions were coded this was the way of looking for distinct concepts and categories in the data. A different colour coding was used for every concept that emerges repeatedly in the interviews. Axial coding is describing a more directed approach in looking at the data, to make sure that all important aspects have been identified. The results were organized according to the themes that emerged

The emerged subthemes were titled by noting the type of ideas in terms of "descriptions or theories" (Cohen et al., 2007, p.368). The subthemes that surfaced from the transcripts were appropriately named according to the description and the theories from the participants. For example, one of the subthemes under implementation of practical assessment activities in the SBA was subtitled 'lack of equipment'.

The subthemes were description that made up the answers to the research questions. They were categorised according to how they integrated to answer one of the research questions. That involved going back to the word document which contained all the subthemes under the prepared guiding themes and sorting them according to categories that intended to address the three research questions.

In the recordings it was found that there were some learner responses that were not relevant to what researcher wanted to achieve in using the instrument. Such data was cleaned. The same exercise was done to teacher interviews data. Observational field notes were also done during audio taped interviews as some gestures by interviewees would assist the researcher in data analysis.

Basically, to analyse the data emerged from the Natural Sciences test at the stages of the pre-and post-test and interviews, descriptive statistics and qualitative analytical procedures were applied. Alongside descriptive statistics, a phenomenological analytic approach was also employed. This was to determine any emerging trend regarding the students' understanding of selected concepts in acids, bases and neutrals in terms of characterizing the qualitatively different ways that specific phenomena might have been experienced (i.e. conceptualised, viewed, perceived, understood, etc.) (Marshall and Linder, 2005). This kind of approach was used to enable the researcher to observe the levels of the students' understanding of the acids and bases conceptions before, during and after the intervention through practical work. In fact, in this study, analysis of the impact of practical work in learning acids and bases was done, not the effectiveness as it would be used in a control group. Hence, the recognition of the fact that the results emerged from this study might have been influenced by other factors like tutorials, readings, documents, books and informal environment not only from practical work. To determine the overall impact of the practical work in the learning of the acids and bases concepts, a 'Wilcoxon Signed-Rank Test' for repeated measures was applied as a non-parametric alternative method to the repeated measures t-test (Newton & Rudestam; Pallant, 2005). Figure 2 below presents a summary of an analytical model used in this study.

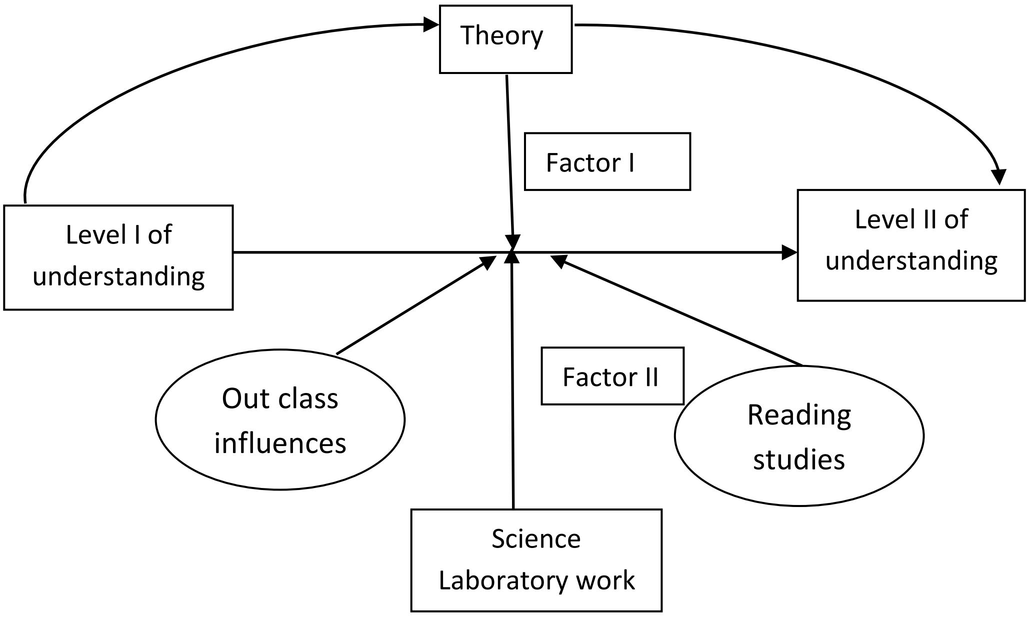

Figure 2: Analytical model to assess the impact of practical work into the transactions

Level I of understanding represents any conditions existing prior to the intervention that is, before the instruction through practical work and/or tutorials. Level II represents the students' understanding after the intervention. Factors I and II are the main factors which were considered as being the most important in terms of its impact in the teaching and learning process of acids and bases concepts. In this case, the impact of practical work into the transactions was observed from Level I to Level II of understanding without ignoring other factors which might have influenced the students' understanding of the acids and bases concepts.

For the interviews a constant comparative method (Merriam, 1998; Dye, Schatz, Brian & Coleman, 2000) in parallel to a phenomenological approach was used. In a constant comparative method, the answers recorded by the interviews were compared constantly and grouped into categories according to their trends in terms of the similarities and differences of the students' responses. This enabled to generate categories of the students' response on the specific concepts provided in the acids, bases and neutrals test and during the practical work on acids and bases. As referred early, the phenomenological approach enabled to qualitatively determine the students' level of understanding of the acids, bases and neutrals concepts in the categories emerged during the interviews.

Raw data from participant classroom observations were analysed on the basis of the completed observations notes. A summary reporting what took place or did not take place in the laboratory environment in relation to the teaching/learning activities, as well as conceptual and procedural knowledge was written. It was also recorded how certain skills were passed on and/or acquired during the laboratory time for each observed session and how practical work activities enhanced the students' understanding of acids, bases and neutrals.

The data collected from the questionnaires were analysed. These data reflected the

i. teachers' practical work teaching experiences in terms of their laboratory current practices; the nature of practical work content and activities and their perceptions about the importance placed on the aims of practical work in the acids bases and neutrals lesson;
ii. students' perceptions about the role of practical work in the learning of acids bases and neutrals lesson; and
iii. teachers' comments and learners' explanations in the questionnaires resulted from open questions (qualitative data). These were analysed and categorized according to their trends (differences and similarities) and then transformed into quantitative data.

3.10 Reliability and validity

3.11.1 Reliability

Reliability is the degree to which an instrument yields stable and consistent results. Joppe (2000) defines reliability as…*The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. (p.1).* Rule et al (2011) believes that conducting research properly will improve the quality of the research and contribute to its trustworthiness. To ensure reliability the instruments were piloted with non-participating school to test it they are workable and will measure what they are supposed to measure.

3.11.2 Validity

The Validity asks the question whether instruments are measuring what we want to measure. The use of more than one instrument guarantees the validity of the data collected for the study. Triangulation is a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell &Miller: 2000). To ensure validity of the research findings triangulation was employed by the use these instruments: pre-test, intervention, observation, post-test, and interviews. Post-test was used to evaluate the impact the intervention in changing the results of the pre-test. Also the instruments we checked by the experienced and well-informed professor in the field of education research. In this study it was of particular interest in terms of the validity to look at the content and construct validity. In the light of these two types of validity, a senior teacher responsible for teaching the Natural Sciences topic checked the content validity, that is, he determined the extent to which the instrument covered the domain area of the content (Cohen et al., 2000).

Two experienced professors checked the item's quality before the pilot study also subjected the instrument to construct validity (Strydom, 2013). Early development and pilot testing as the fourth step focuses on developing a prototype of preliminary intervention, conducting a pilot test and applying design criteria to the preliminary intervention concept. The combination of the two kinds of validity (content and construct) allows reinforcing the overall acceptance of an instrument in terms of the content coverage, structure and level of the construction and appropriateness of the test items (Neuman, 2003; Mulder, 1986). In addition, the learners' responses on the pilot test helped to improve the formulation of questions avoiding in this way the redundant wordings as well as questions with more than one response, as was found from the responses in the pilot test. Thus, the level of understanding in the test was in general greatly improved.

Besides the tests, this study yielded qualitative data by means of the interviews and classroom observations. Thus, to address the issues of validity and reliability, triangulation of data sources was used. Triangulation usually involves using alternative data sources or collection processes to corroborate data. For instance, in a study in which the interactions of a group of students were observed, personal records or interviews could corroborate the observational data. In this case, the notion of 'trustworthiness' that integrates issues of credibility, confirmability, transferability and dependability was introduced to replace more conventional measurements issues in quantitative design (Cohen, et al., 2000; Lincoln & Guba, 1985). To ensure the validity of the interviews, the semi-structured questions used in the interviews some of teacher questions overlapped with those learners and even some pre and post-test questions. This was done to determine whether or not the data yielded by means of interviews compared reasonably well with those of the pre- and post-test measured the same in terms of the students' conceptions of acids, bases and neutrals after doing practical work (Cohen et al., 2000).

In order to avoid the threats to the validity of the study as a result of the possible roles that can be assumed by the informant and the respondent, relationships of trust with the interviewed learners during tutorials and laboratory classes were established. In addition, also of interest was the credibility issue as using different data sources, methods and referential adequacy triangulated the data yielded in this study. Adequate storage of audiotapes of interviews was also therefore ensured (Lincoln & Guba, 1985). The researcher spent considerable time as a participant observer with the students. This probably contributed to the reduction of possible reaction effects that could arise from the interactions with the students (Cohen, et al., 2000).

3.11.3 Research Ethics

In protecting the rights of participating respondents in the study code of ethics were observed. Permission to do the research was requested from the university's ethics committee. Another request for permission to conduct the research was sent to Superintendent General of the Eastern Cape Department of Basic Education.

Streubert and Carpenter (1999) identify two sets of ethical considerations when qualitative approach is employed. This was done by ensuring that all participants in this research have freely consented to participation, without being coerced or unfairly pressurized and could decide to withdraw at any time. Tom Beauchamp and Jim Childress (1983) list four principles of ethical concerns to be considered before doing a research.

The first ethical principle is autonomy which according to Polit & Hungler (1999) respect the rights of self-determination and the right to full disclosure. The participants were informed of the nature of the study and what to expect as the participant in the study, that no surprises are awaiting them.

The second principle is the beneficence which ensures the research will display benevolence/magnanimity and fairness to the participants. Non-maleficence as the third ethical principle was also guaranteed to participants. This is the principle that ensures parents that their children are in safe hands all the time and no harm will be done by the research.

The last ethical principle that was considered was justice: particularly equity. Participants were guaranteed the protection of their anonymity in the report by implementing appropriate confidentiality procedures.

The same letter to request permission of non-participating respondents to be part of the initial stages of the research was used.

3.12 Conclusion

This study was designed with the aim of investigating the role of practical work in the teaching and learning of acids, bases and neutrals in primary schools in Eastern Cape South Africa. Both quantitative and qualitative methods were employed to achieve the aims of this study. These methods included five types of research instruments, namely: (i) Acids, bases and neutrals Test at the stage of pre-and post-test; (ii) Classroom observations; (iii) Learners' Interviews; (iv) Teachers' Interviews;. This chapter described also the development of the research instruments including piloting of the instruments, issues of validity and reliability, data collection procedures, methods of data analysis and interpretation and ethical issues.

Chapter 4

Results and Discussion

4.1 Introduction

In chapter 3 the methodology used in the study was discussed at length. In this chapter information will be presented to answer the main research question, namely:

How does practical work influence teaching and learning of acids, bases and neutrals in Natural Sciences?

This section outlines and describes the results of this study with the purpose of developing an understandable account of analysis from the views of the participants about the influence of practical work in teaching and learning of acids, bases and neutrals in natural sciences. This chapter is arranged in response to the research sub-questions that address the above main research question.

4.2 What was learners understanding of acids, bases and neutrals before the practical-based lessons?

Before the learners were taught they were given a pre-test. This test was designed to determine learners' prior knowledge on acids, bases and neutrals. Their prior knowledge included general knowledge that they had of acids, bases and neutrals and also the knowledge that they gained from the lessons on this topic delivered by their science teacher. This test aimed at establishing

a. if learners know the physical properties of acids and bases.
b. if they can identify acids, bases and neutrals

As they were writing this test they were monitored by the researcher, their class teacher and facilitators from the NMB Science and Technology centre. This is a team that collaborated in teaching in all the sampled schools. The only person that had to change as the team moved from school to school was the Natural Science teacher. The team wanted to make sure that learners do not share their responses. As it is explained in chapter three pre-test was given to all three schools with the aim of establishing their prior knowledge. The test was marked by two members of the team.

4.2.1 Pre-test at School A

Table 5 and Figure 3 represent the achievement of learners at School A in the pre-test. The learners' responses to the test revealed that leaners have better understanding of acids compared to that of bases. In fact, they had no idea as to what bases were. This is understandable because acids, bases and neutrals are taught for the first time in grade 7. Some learners (A7, A16, A25 and A30) got zero marks in the pre-test. In response to the question "Are acids edible?" more than 80% of the learners indicated that acids are not edible. Not a single learner answered question 4 which seeks to establish as to what learners understood about bases. Again, considering that this terminology (base) is not used in any substance at home one could give credit. The term acid is used very commonly at home even though at time it is used incorrectly.

Table 5: Pre-test results of school A

Learners	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
Pre-test	13	9	10	4	4	2	0	15	10	13	5	1	4	4	6	0	12
Learners	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34
Pre-test	9	6	8	6	3	6	1	0	7	7	9	11	0	12	8	2	1

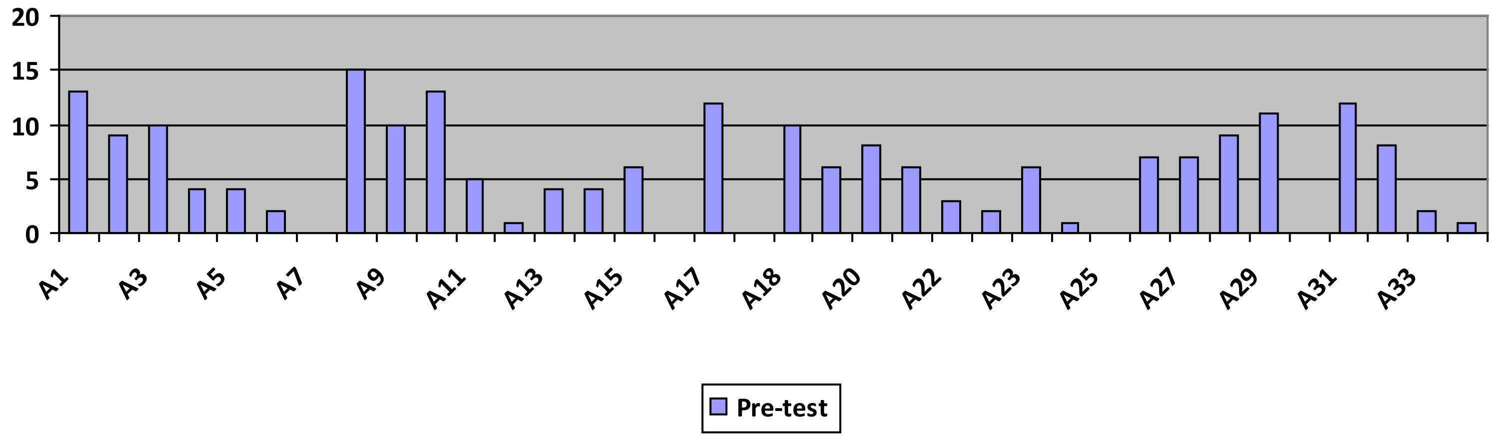

Figure 3: School A Pre-test marks

Table 6: School A Pre-test summary

LEARNER	PRE-TEST
LESS THAN 40%	**23**
40% and more	**5**
80% and more	**0**
Pre-test average	**6**

As Table 6 represents, five learners achieved 40% and above in this test with only two learners passed the pre-test with 15 and 12 marks. No learner achieved more 80%. Most of the question were level one questions which required knowledge. This, therefore, indicate that learners at school A had little knowledge in as far as acids, bases and neutrals are concerned.

Some questions revealed very poor English proficiency from learners. Consider the following question:

Use the words below to complete the following paragraph.

blue; bitter; rough; sour; indicator; red; slippery; corrosive; alkali; neutrals

A base that can dissolve in water is called an __________. An ___________ is a dye that changes colour in chemicals. In this question you would expect responses chosen between indicator and alkali. Answers such as corrosive neutral and bitter were also part of the responses received. Blatant demonstration of no knowledge of prepositions. However, this was just 5% of learners that fall into this category. The question most learners got correct was the one that asked about the taste of acids. They knew acids are sour in taste.

4.2.2 Pre-test at School B

Pre-test a results from the school are presented in Table 7 and Figure 4 below. Their responses to questions indicate that they had better knowledge of acids than bases and neutral substances. More learners could give good examples of acids as opposed to examples of bases. In this school all learners did not know examples of bases and neutrals. The question of language was also evident in this school as discussed in school A.

Table 7: Pre-test results of school B

Learners	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19
Pre-test	12	0	6	4	6	1	0	9	7	2	12	5	10	4	4	3	0	1	5

Learners	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
Pre-test	7	11	0	1	8	3	2	6	1	0	5	7	2	11	3	2	6	1	1

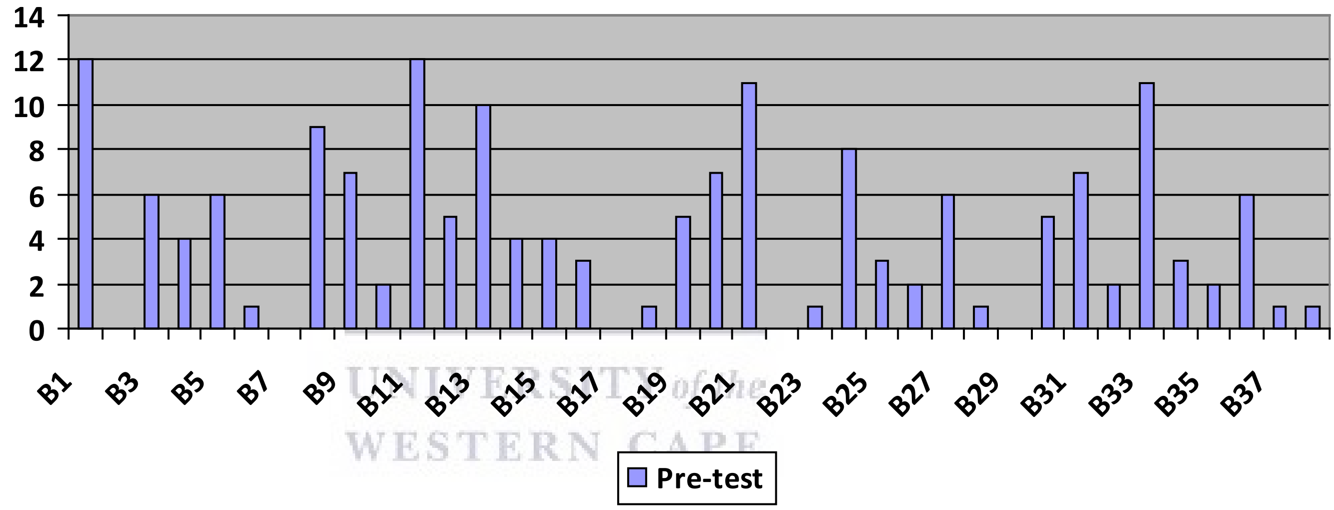

Figure 4: School B Pre-test marks

Figure 4 shows that in school B, 4 out of 38 learners (B7, B17, B22 and B29) got zero in the pre-test. This shows that these learners have limited understanding of the topic. Only two managed to have 12 correct answers out of 24. The learners are B2 and B11. These results show that only two learners achieved a 40% pass in this school's pre-test.

Table 8: School B Pre-test pass rate

LEARNER	PRE-TEST
LESS THAN 40%	**32**
40% and more	**6**
MORE THAN 80%	**0**
Pre-test average	**4**

4.2.3 Pre-test at School C

A total of 38 learners participated in the pre-test. As can be seen in Table 9 and Figure 5, the learners at this school struggled with questions in the pre-test. One learners did not get any answer right and the overwhelming majority achieved less than 40 %. It was clear that learners from this school came to class with a very limited understanding of acids, bases and neutrals.

Table 9: School C Pre-test of School C

Learners	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19
Pre-test	5	8	3	10	6	2	1	7	7	3	5	2	9	13	5	3	1	8	4
Learners	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38
Pre-test	1	4	7	0	6	2	5	4	2	8	2	9	11	8	7	5	2	6	3

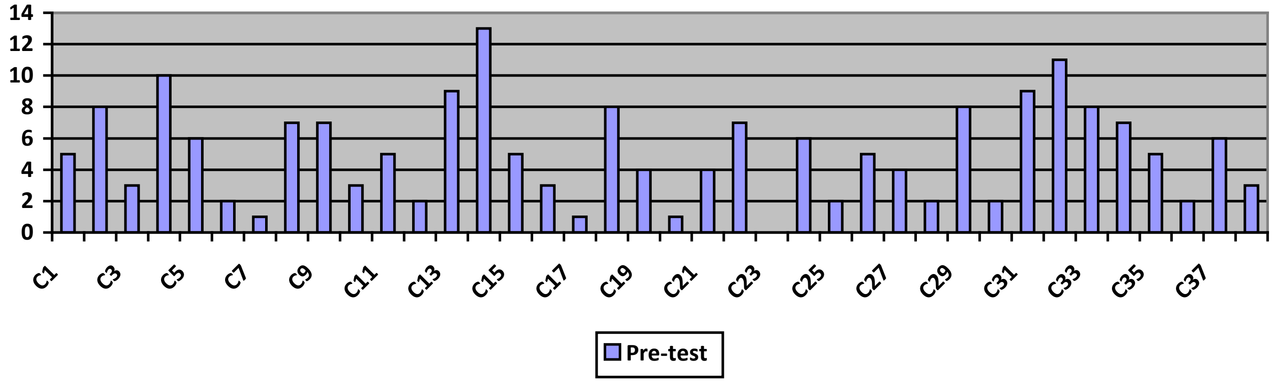

Figure 5: School C Pre-test marks

A summary of learners' achievement in the protest (see Table 10) highlights the challenge in this topic as 37 of the 38 learners achieved less than 40 % in the pre-test.

Table 10: Pre-test and Post-test pass rate

LEARNER	PRE-TEST
LESS THAN 40%	33
40% and more	5
MORE THAN 80%	0
Pre-test average	5

4.3 How were the practical-based lessons implemented?

The practical lesson was planned by the researcher and the four facilitators with specific aims as stipulated in the CAPS document (CAPS, 2011).

Specific Aim 1: Doing Science

Specific Aim 2: Knowing the subject content and making connections

Specific Aim 3: Understanding the uses of Science.

As the science centre team is helpful to the local school it has the luxury of taking three hours for their session in all the schools. According to the CAPS document time allocation for acids, bases and neutrals is 2 weeks, 3 periods per week. This lesson was video recorded. The observation was conducted with the aid of observation schedule which was completed during the lesson.

1. One facilitator introduced the lesson. The introduction served to take the lesson from known to unknown. In her introduction the facilitator used short animated videos downloaded from YouTube on acids bases and salts. The excitement was unavoidable in the learners in all three schools sampled. It was evident that this was the first time they ever been introduces to such learning activity.

2. Learners were then asked to name acids they know and why do they say those are acids. Some were asked about bases. Some of the responses received were: “Coca cola; Refresh; Eno; vinegar are acids”. Reasons supplied were that they produce bubbles and others are sour. No learner could give any example of a base.

3. The apparatus and the substances that were going to be used in the practical work were supplied to groups. The aim of the task was to investigating common beverages to determine whether they are acids, bases or neutrals (such as water, tea and rooibos, coffee, milk, fruit juices, fizzy drinks) to test whether they are acids, bases or neutrals. In complying with CAPS learners had to do Science by engaging themselves in practical activities. Before doing practical they were given opportunity to predict the taste and feel some weak household acids and bases e.g., vinegar, baking soda, lemon juice, soap, apples, egg white, oranges and milk of magnesia. It was interesting to note how some learners were resistant to taste some items.

4. The following table was used for this exercise.

Table 11: Practical work worksheet

	Predictions							After tasting						
Vinegar	Bi	So	Sa	Sw	A	B	N	Bi	So	Sa	Sw	A	B	N
Baking soda														
Lemon juice														
Soap														
Apple														
Egg white														
Orange														

Milk of magnesia														

Keys:

Bi – bitter So – Sour Sa – Salty Sw – Sweet

A – Acid B – Base N – Neutral

For taste they were to choose from tastes given: bitter, sour, salty and sweet. They had to choose between smooth and rough for the feel of substances. Different tastes were reported about apples and oranges. Most reported that apples and oranges are sweet while some reported a sweet taste. Learners recorded their predictions for reference at a later stage. During this activity, there were more learner – learner activities taking place. Teachers were supervising the whole process.

They were later instructed to start the practical work. The groups were supplied with the items to be investigated. Excitement was evident in the learners as they were engaging in the investigation. After tasting they were required to feel some solutions by rubbing them between the thumb and forefinger. After every taste, they were requested to wash their mouths to be ready for the next taste. The same process was followed for every feel activity, namely to wash their hands.

The second part of the investigation was to use indicators to determine if solutions are acids or bases. The groups were supplied with unlabelled acids, bases, neutral substances and indicators. They were required to observe the colour changes as the indicators are added to either an acid or a base. Items supplied were as follows: Indicators: - Red litmus paper and blue litmus paper. Household substances: - Vinegar, tartaric acid, antacids, lemon juice, shampoo, soap, bicarbonate of soda and liquid soap (with no lemon additive). Although all groups started the practical work at the same time and were fully engaged in the task, the task could not be completed in the single period as allocated in all schools. This was amongst other reasons due to playfulness of some group members. Some groups had to redo the activity as they either spilt their substances or added substances without following given instructions. Without proper supervision, this happens a lot in practical work experiments.

4.4 What were learners' understanding of acids, bases and neutrals after the practical-based lessons?

Learners were given a post-test to write after the practical lessons on acids, bases and neutrals. The post-test was implemented at each of the three schools that participated and was conducted as part of the class tests administered by the science teacher. The following are the results obtained at each school.

4.4.1 Results in post-test at School A

Table 12 and Figure 6 highlights the improvement of the results of learners of School A obtained from pre- to post-test. Table 12 indicate that the learners at School A improved in their knowledge of acids, bases and neutrals although some improved with very small margin except for learner A29. This is the improvement of 97%.

Table 12: Pre-test and post-test results from school A

Learners	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
Pre-test	13	9	10	4	4	2	0	15	10	13	5	1	4	4	6	0	12
Post -test	22	16	12	13	10	19	2	24	18	23	7	12	9	7	10	6	17

Learners	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34
Pre-test	9	6	8	6	2	6	1	0	7	7	9	11	0	12	8	2	1
Post-test	21	13	16	11	12	15	8	1	13	16	13	10	6	20	12	9	3

Figure 6 demonstrates clearly how well learners in school A did in the post-test compared to the pre-test. Trend lines are added to demonstrate the impact of intervention which is measured by looking at the difference in the pre-test and post-test results. The trend line of post-test is higher than the one on pre-test. This means that better results were obtained in the post-test.

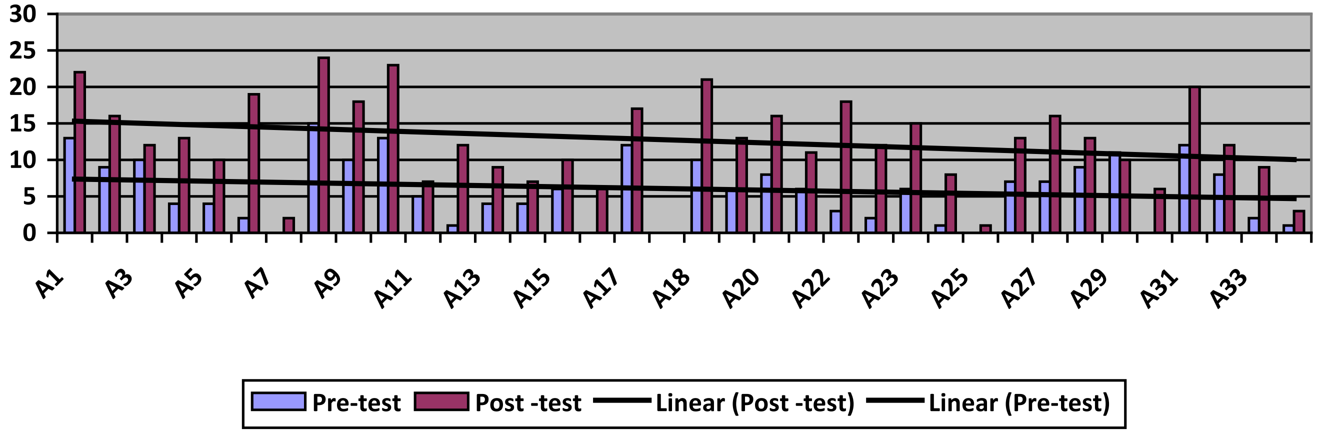

Figure 6: School A Pre-test vs post-test marks

Table 13: School A Pre-test and Post-test pass summary

LEARNER	PRE-TEST	POST-TEST
LESS THAN 40%	**23**	**8**
40% and more	**11**	**26**
80% and more	**0**	**6**
Pre-test average	**6**	
Post-test average	**13**	

Table 13 indicates that the average mark of post-test is higher than that of pre-test. Also the are less learners in post-test that achieved less than 40%. Unlike in the pre-test at least one learner managed to achieve 80% which is level 7.

4.4.2 Results in post-test at School B

Table 7: Pre-test and post-test results from school B

Learners	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20
Pre-test	12	0	6	4	6	1	0	9	7	2	12	5	10	4	4	3	0	1	5	7
Post-test	17	3	16	13	17	19	8	13	18	20	19	17	18	21	10	6	1	4	16	10

Learners	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
Pre-test	11	0	1	8	3	2	6	1	0	5	7	2	11	3	2	6	1	1
Post-test	22	4	9	18	14	11	16	8	0	13	10	8	22	7	13	19	7	15

The trend lines show in figure 7 display similar trends compared to figure 6 in as far as pre-test and post-test results.

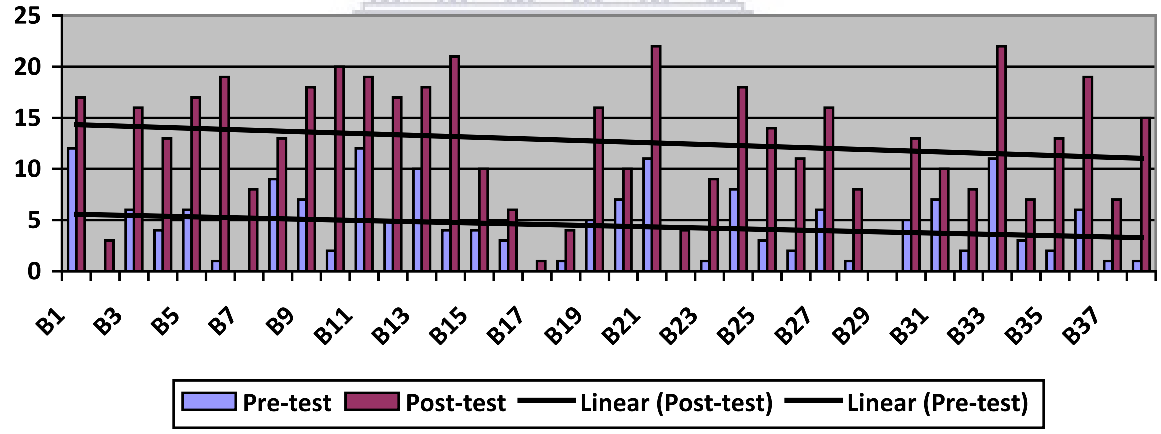

Figure 7: School B Pre-test and post-test marks

Table 8: School B Pre-test and Post-test pass rate

LEARNER	PRE-TEST	POST-TEST
LESS THAN 40%	32	11
40% and more	6	27
MORE THAN 80%	0	7
Pre-test average	4	
Post-test average	13	

In School B, 7 learner achieved 80% in post-test. This his is the school that has greater improvement on average compared to both schools. The increase in average mark is 7, the highest in the three schools sampled. The school has the least mark average in pre-test when comparing with the other two schools. One learner got zero even after intervention.

4.4.2 Results in post-test at School C

Table 9: School C Pre-test and post-test results from school C

Learners	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
Pre-test	5	8	3	10	6	2	1	7	7	3	5	2	9	13	5	3	1	8	4	1
Post-test	19	17	9	22	18	15	6	19	14	11	8	2	19	22	16	12	6	20	14	5

Learners	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38
Pre-test	4	7	0	6	2	5	4	2	8	2	9	11	8	7	5	2	6	3
Post-test	17	13	3	13	10	9	12	9	18	11	20	19	14	17	12	9	13	6

Figure 8 below shows the trend line of post-test which is higher than that of pre-test. This lines indicates the improvement very clearly.

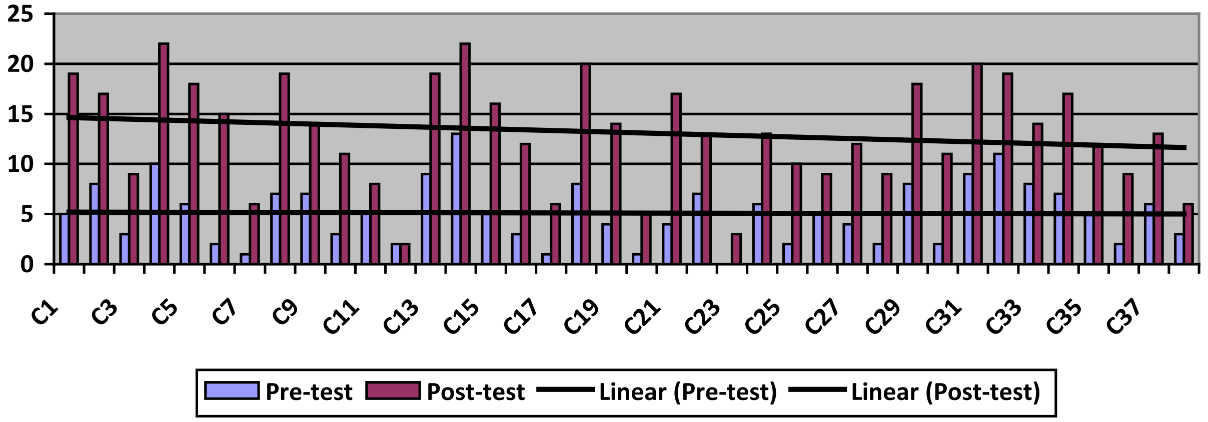

Figure 8: School C Pre-test and post-test marks

Table 10: Pre-test and Post-test pass rate

LEARNER	PRE-TEST	POST-TEST
LESS THAN 40%	**37**	**7**
40% and more	**1**	**31**
80% and more	**0**	**8**
Pre-test average	**5**	
Post-test average	**13**	

Table 10 summarise the results of pre-test and post-test at school C. It clearly shows that learners did better in post-test than in pre-test. The average mark of the post-test in higher than that of the pre-test. Compared to School A results, eight learners achieved 80% and more. The school got more quality in the post-test results compared to the other two sampled schools. Even looking at just meeting minimum pass requirements (40%) one would see that the school had more learners meeting the requirements. In this school there are learners who improved with big margins.

4.5 What were learners' perceptions of the practical-based lessons?

To obtain a more comprehensive picture on how practical work influence learners understanding of concepts in acids, bases and neutrals the students were interviewed for qualitative interpretations. Thus, this section presents the students typical responses about practical works in learning acids, bases and neutrals in a detailed way. Each participant was assigned with a code and number for ease reference. Learners' codes are represented in the following table

Table 12: Learners' Codes

	Learner 1	Learner 2	Learner 3
School A	AL1	AL2	AL3
School B	BL1	BL2	BL3
School C	CL1	CL2	CL3

4.5.1 Learner's attitudes towards practical work

A large majority of students claimed they learnt from practical work but there was no consensus as to whether they believed that in order to learn science they needed to do practical work.

BL2: ...*You learn more new things during practicals.*

CL1: *Learning more on how to answer in practical.*

CL3: *...Practical work enhances my learning. It helps me to understand better.*

AL2: *...Practical work helps us because we are able to see it instead of just talking about it.*

Certainly, an overview of the student's attitudes towards practical work shows that they do feel positive. They believed that practical work enables them to learn more on science. Thus, these comments summarize the idea that doing practical work enables students to have a better understanding of science. Most of the students articulated that they learn from practical work in science lessons, because they were able to see how everything works instead of being told what would have happened. Hence, in this study learners indicated that practical lessons enabled them to know scientific concepts.

4.5.2 Conducting of practical work at the school

The students were asked on how often they do practical work at school. The following were their responses:

AL3: *Umm sometimes we do it all day.*

BL2: *I would say twice a month, I don't know Sir.*

AL2: *I think about twice in the month.*

CL1: *It would depend on the topic that we are like doing.*

CL3: *I think once in a month.*

The comments above show inconsistencies within the student's response. They were not sure on how often the practical works were done. This might be due to the reason that they don't have a stipulated timetable for practical works at the laboratory or a reason that they do not have a laboratory. All the learners cited that they do practical work in their classroom:

BL1: *....in the classroom. It's a lot of fun to do the experiments.*

CL2: *In the classroom mfundisi (teacher) shows us sometimes. If we had a lab we could see more of these things.*

AL2: *In our school we don't have like a lab so that we conduct tests or anything that will helps us to do.*

This study found that the learners felt the need for a lab so that they would be able to do more practical work in science lessons and to get more involved in their science lessons. Practical work should be allocated in the school time table.

4.5.3 Practical work and teacher demonstration

In this study, the general findings on how practical work is done and whether their teacher demonstrates by showing them how to do it. Below are the responses from the students:

CL3: *In my school, we do it in groups...and our teacher demonstrates to us.*

BL1: *Our teacher demonstrates the practical work, in return we show him what we understood from that, from all that practical work he has done we show him in return and he does it.*

BL3: *In a group. He demonstrates how we must do...he does not just give it to us and say do it yourselves.*

In this study the general findings show that the large majority of students they do practical works in groups. The point that students above are making is how teacher involvement can help them to understand the practical work. Indeed, students in this study do benefit through teacher demonstration from being able to discuss and reflect in order to prevent the confusion from doing practical work on their own.

4.5.4 Preferred form of practical work

This section discusses the findings on the preferred form of practical work. The students were asked to state and explain the form of practical work they prefer to be used in their lesson. Most of the students, who claimed that they enjoy doing practical work, felt that this was because of the opportunity they had to work in groups citing that it enables them to share ideas together and they also learn in the process. The responses of the student are listed below:

AL1**:** *I prefer doing practical's in group work because when you work in a group you understand more because...there are those who understand and those who do not understand.*

AL3*: I enjoy practical work as a group. Because you don't only use your own answer but you also get like to hear what the other learners are thinking ...like brainstorm your ideas together and you would learn in the process.*

CL2: *Its better when you are doing it in groups...you can understand it easy***.** *In a group you are not alone. Maybe someone will ask a question you did not understand or maybe you understood, you will help each other*

The comments above typify that students prefer doing practical lesson in groups because it enable them to brainstorm their ideas and help each other in the process. According to Toplis (2012) practical work that is done in groups' influences positive fondness and better understanding. This was similar to the responses that were obtained in the study as shown in the above comments. However, there was a student who did not like practical work. This lack of enjoyment develops as a result his dislike:

> BL3**:** *I would choose the ordinary lesson because I get all the stuff I need during the lesson...when a question comes up, I am able to answer*.

The above comment suggests that the student's behaviour in a class does have an impact on the rest of them not only during practical work lesson but on a student's attitude to practical work itself.

4.5.6 Value of Practical lesson

With regard to how students feel about the value of practical work that was conducted by teachers from science centres some typical responses are shown below:

> AL3: *It was great because now I know what an acid is...and I know what a base is and a pH7*
>
> CL2: *...We wrote a test and it was easy to answer as we were already taught.*
>
> CL3*: I learnt a lot since I didn't know what a base was and what a neutral is...now I know the difference between acids and bases.*

This theme has shown that learners were able to learn from science centre's teachers. They could explain what they saw or were doing but they were not able to give explanations behind the idea. Thus, this proposes that in this study whilst student's claim that they learn more from practical work, what they really are claiming is that they are able to see 'phenomena', there is little to suggest they actually are able to link scientific ideas with the phenomena they see.

4.5.7 Comparison of practical lesson to normal lesson

In addition, a comparison of practical lesson to normal lesson showed that the majority of the students prefer practical lesson because they regard normal lesson boring and confusing at times especially when their teacher tells them what to remember rather than working it themselves. The student views were as follows:

CL1*: … a normal lesson is more boring because the teacher would be telling us things whereas; some of us prefer working with our hands which is quite interesting.*

AL2: *...Practical lesson is more fun and we understand the topic or subject being raised.*

Thus, in this study it was established that students prefer practical lessons especially when explanations are not clear for them to understand. It could have been the fact that that teacher talk was often seen as boring and uninteresting and that, as such, practical work provided a break from theory work.

4.6 What were teachers' perceptions of the practical-based lessons?

To obtain a more comprehensive picture on the significance of practical work, teachers were interviewed for qualitative interpretations. Thus, this section presents the teachers typical responses about practical works and investigations in Natural Science.

Teacher coding: Science Teacher from school A – TA

Science Teacher from school B – TB

Science Teacher from school C – TC

Question One

As part of formal assessment tasks in Natural Sciences you have to conduct practical work and investigations. How easy do you find these activities? What challenges if any do you encounter?

Teachers' Response

All three teachers agreed that it was important to have a formal assessment tasks of practical work and investigation in natural science in their curriculum (CAPS) document. TA agreed to find easiness in the formal practical assessments and TB teacher confessed to be facing challenges of lack of understanding of the content and shortages of apparatus (experiment instruments) at the school. TC believes she does not experience any problems with the way she is teaching.

TB: *You know sir. With experiments, one has to be sure. Some of the experiments are dangerous. If you hurt a learner, you'll be in trouble. We need more training.*

TC: *In the donkey years I've been teaching, I never receive received any criticism. My leaners are making it in life.*

Question Two

Do Natural Science teachers of the school perform practical work in all grades? How would you rate level of comfortability in lower grades?

Teachers' Response

All teachers do perform practical work in all grades though they all agreed that the requirement in CAPS allows them to perform practical work in grades 4-9 in natural science. It is generally easy to do practical work with higher grade as they require less supervision time and monitoring than lower grades since it is difficult to control a class of 40 lower grades learners in practical work. TB and TC rated themselves low on their comfortability to do practical work in lower grades. TA was felt confident about how he conducts practical. However, he indicated that …*most of teaching time is used in preparing for practical work. You have to collect the apparatus that are haphazardly stored in the store room.*

Question Three

Do you have science kit in your school that will be enough for all the grades? Is your science kit enough to enable you to let learners take part in practical work, not demonstration?

Teachers Response

Teacher from School A has a science kit that they were given by the department of education almost 20 year ago. He sometimes has to borrow or uses his own money to buy the materials do the practical work. The other educators from School B and C have the kit but an in-complete kit. Because of missing kits and incomplete kits learners were not able to fully take part in practical work.

During the school visits for school readiness the researcher was in the team of district officials visiting the schools in the now Nelson Mandela Bay district. In the trip two of the primary schools visited had science laboratories but the rooms were being used for other purposes. One was sort of a kitchen for whatever reason. NS teacher (Tx) at the school said he is in a process of talking to the principal to allow him to use the room as his “science room’. This is a so called ex-model C school.

Question Four

How often do you perform practical work in Natural Science?

Teachers Response

The teacher from School B admit that they seldom perform practical work in Natural science as it is time consuming, and they perform practical work when it is convenient to them, to comply with curriculum requirements. School C teacher said at least once a term unless there is a formal practical assessment required as per curriculum. TA teachers cited that due to the absence of the science kit practical work assessments are carried out theoretically (the teacher uses simulations) so that learners may imagine through pictures and drawings of what an experiment entails and the results.

In addition to this teacher (Tx) from ex-model C school confessed that they are not doing practical work but he uses videos he downloaded from YouTube and project them on a screen.

Question Five

Is practical work in your school done by all Natural Science educators in all grades? If not, what measures do you have in your school to make sure that it is done by all?

Teachers Response

There is only one Natural Science educator in School A and one educator from School B. School C has two Natural Science teachers. The respondents stated that not all grades do practical works in Natural Science, the reason being that they (Science Teacher at school B – TB) …*do not have the space "big enough" to perform the practical work*.

TA noted that as the only science teacher at the school *…It will cost me time to that in grade 4 and 5 as they too many.* The science kit should be available in full to all schools and if possible the school without the kit may borrow from another school so that all the schools may do the practical assessment. And further to that the Science laboratories be available in all schools.

Question Six

How often do science educators of your school receive support in performing practical work? Who normally provides such support?

Teachers Response

Both teachers stated that once a year, the School Management Team (SMT) promises to purchase the science kit when they make their yearly budget. But they also said that the SMT promises are on paper but usually do not come to pass. They all noted that they receive kick-start work shop once every first term of the year. TB added that …*no experiments are done on those workshops as they are mostly done after school. They are short sessions.* The teacher also revealed that they never saw their Natural Science subject advisor (SES) to support them except during moderations.

This, the researcher also heard from the teachers during the school readiness programme at the beginning of the year. Even the NS teacher (T_x) at one of the ex-model C schools visited by the research (as a member of the team visiting the schools for the programme) was complaining about the same thing.

Question Seven

How can you describe the learner attitudes and reactions in natural science after we have done practical work?

Teachers Response

All three teachers cited that the learners are excited, happy and willingness to learn more. Learners respond positively during experiments.

Question Eight

Do you think science apparatus and material enhances pupil learning? If you do, in what way do you think these resources enhance learning?

Teachers Response

The teachers did agree that science apparatus and material enhances pupil learning. TB added that *the science apparatus provides a different atmosphere where learners had to experiment, observe and write their findings. This gives a room for all learners including those that are weak or slow to be at the same level with others*. TA further noted that *…moreover, the science apparatus removes the chalkboard environment and place everyone in a lab situation although in class (laughing) which is a different form of learning.*

4.7 Conclusion

This chapter highlighted the findings obtained after answering each of the research questions. The following chapter provides a summary and conclusions of the study.

Chapter 5

Conclusion

5.1 Introduction

The focus of this study was on the impact of practical work in the teaching content in Grade 7. The study explores the viewpoints and experiences of teachers and learners in the teaching of acids, bases and neutrals in Grade 7. The main aim of the investigation lies in the research question which is:

How does practical work influence teaching and learning of acids, bases and neutrals in Natural Sciences?

The study investigates the effect of Practical Work in teaching and learning of acids, bases and neutrals in Natural Sciences. Observations and interviews were conducted by the researcher on the selected schools. The aim of this chapter is to analyse the results, make conclusions, summarise the findings and come up recommendations based on the analysis and outcomes of impact of practical work in teaching and learning Natural Science.

5.2 Overview of the thesis

This study is made up of five chapters which were developed to respond to the research questions of the study. The summary of the chapters is organised as follows:

Chapter One: This chapter provides a rationale of the study focussing on the background and context to the study. It also highlights the research problem and research question identifying the significance and limitations of the study. The rationale of the study was directed at using practical work as a teaching strategy in an attempt to provide learners with an opportunity to learn curriculum content by exploring and being engaged in hands-on practical activities. The foundation laid by this chapter ultimately provided a background for the other chapters of the study that followed.

Chapter Two: In this chapter investigation was more on what other researchers understand and discovered about the topic in question. Theoretical frameworks underpinning the study were also discussed in this chapter. The literature review dealt mostly with the influence of practical work in learning and teaching acids, bases and neutrals in Natural Sciences. International and South African literature was reviewed with the aim of observing the trends and comparing the contexts. The focus was more on recent studies. Literature review revealed that doing of practical work is not significantly dependent on whether teachers have physical resources (e.g. laboratories, science apparatus or mobile laboratory stations). It emerged that those who are motivated to do practical work will find ways to do so even in the most poorly resourced of schools. Conversely, those who are not motivated will not do practical work even when they have access to the best of resources. Also, motivated learners in turn motivate teachers, who then provide more interesting kinds of practical work.

Chapter Three: This chapter discussed the research design of the study, study sample, procedure used to design instruments, data collection and data analysis techniques used to get the research findings. The study used a mixed method design to collect data. The data was obtained through the use of qualitative instruments which entail observation and participant interviews and quantitative instruments that entail pre-test and post-test. The qualitative approach applied in the study includes interviews of both teachers and learners and observation of the intervention. This approach was chosen because in the approach a researcher is ideally an objective observer who neither participates nor influences what is being studied.

Chapter Four: This chapter outlines and describes the results of the study with the purpose of developing an understandable account of analysis from the views of the participants about the influence of practical work in teaching and learning of acids, bases and neutrals in natural sciences.

Chapter Five: Results analysis, conclusions, summary and recommendations were all presented in this chapter.

5.3 Main findings of the study

(i) Learners knowledge from pre- to post-test.

The findings show that learners understanding of acids, bases and neutrals improved from the pre to the post-test. Even though the teacher had already conducted the lessons on this topic with their learners, the pre-test revealed that very few of the learners had an understanding of what acids, and bases were about. In the pre-test the overwhelming majority of learners had no idea what a base was. Considering that this terminology (base) is not used in any substance at home one could come to the conclusion that it was something new to them. Though, the term acid is used very commonly at home most of the time it is used incorrectly. After the implementation of the practical lesson there was a marked improvement of learners' knowledge of the topic as the majority of the learners test scores improved in the post-test.

(ii) **Implementation of practical work in teaching acids, bases and neutrals**

Although all groups started the experiment at the same time and were fully engaged in the experiment, the experiment could not be completed in the single period at the same time. This was amongst other reasons due to playfulness of some group members. Some groups would have to redo the activity as they spilt their substances before readings were taken. Without proper supervision, this happens a lot in practical work experiments.

As the observation schedules were analysed, it indicated that there were more learner to learner interactions in these interventions. Subject teachers from school A, even commended the fruitful discussions he overhead from the groups as he moved around from group to group. Some learners that are known to be shy in this school were observed to be questioning other learners. Some 'amazingly' opened up as the teacher indicated.

One of the findings of the practical lesson was that, according to Teacher B, the teacher needs to focus on helping learners to restate their questions in useful ways. This can be prompting each learner to reflect on and examine his or her current knowledge. When one of the learners comes up with the relevant concept, the teacher takes upon it, and indicates to the group that this might be a fruitful avenue for them to explore. They design and perform relevant experiments. Afterwards, the learners and teacher talk about what they have experienced, learnt and how their observations and experiments helped (or did not help) them to better understand the concept. Accordingly, teachers need to encourage learners to constantly assess how the activity is helping them gain understanding. By questioning themselves and their strategies, learners would ideally become "expert learners". So, the teacher's main roles become to encourage this learning and reflection process (Harlen, 2004 and Supovitz and Turner, 2000).

During practical work learners were interacting with the apparatus using senses and showed understanding of how to use them. Since all human senses are connected to the brain it makes easy for them to remember what they did. In the experiments learners were using their senses to determine whether substances are acids, bases or neutrals. Thus, through practical work knowledge becomes embedded in all the senses that are involved during the lesson.

(iii) Perceptions of teachers and learners about the practical approach to teaching acids, bases and neutrals

The teachers felt that although they were constrained to use teacher demonstrations because of the problems with resources (science kit), their demonstrations were done in such a way that learners could get a solid understanding of the relevant content. For most teachers, practical work encompasses what teaching and learning science is all about. However, there is a growing debate surrounding the effective and affective value it has on students and their learning (Abrahams 2009; Abrahams & Millar 2008; Hodson 1991; Millar 1998).

An overview of the student's attitudes towards practical work shows that they do feel positive. They believed that practical work enables them to learn more about science. Though it cannot be concluded that they understand the scientific theory more. This was also reported in the studies of Toplis and Allen (2012), who argues that practical work enables learners to learn more. However, this does not automatically mean that they are in fact able to understand the scientific theory behind the activity.

The study also established that when learners perform practical works in groups it enables them to brainstorm their ideas and help each other in the process. This tends to influence positive enthusiasm and better understanding on the subject. Also, teacher involvement plays an important role during practical work as it can help the learners to understand the practical work. Learners benefit through teacher demonstration from being able to ask questions, discussions and reflections to prevent the confusion from doing practical work on their own

The study also established that when learners perform practical works in groups it enables them to brainstorm their ideas and help each other in the process. This tends to influence positive enthusiasm and better understanding on the subject. Also, teacher involvement plays an important role during practical work as it can help the learners to understand the practical work. Learners benefit through teacher demonstration from being able to ask questions, discussions and reflections to prevent the confusion from doing practical work on their own

Student achievement as well has been shown to improve when teachers have strong content background and pedagogical knowledge. Neither strong content nor strong pedagogical knowledge alone is adequate to increase student achievement substantially. Thus, it is the teacher's ability to transform his or her knowledge of the subject matter and pedagogical knowledge that is so crucial to student achievement. Furthermore, the study established that science laboratory apparatus and material enhances pupil learning. These resources provide a conducive environment where learners had to experiment, observe and write what they observe. This gives an opportunity for all learners including those that are weak or slow to be at the same level with others. Moreover, the science apparatus eliminates the chalkboard environment and place everyone in a laboratory which is a different form of learning space. Having noted that there are learners who struggle to comprehend theory, being in a science laboratory brings a different environment of doing science hands-on.

Even though learners may have an interest to conduct practical work, it does not necessarily imply cognitive learning purely because the context of that learning has become seemingly more relevant to the learner. Just because learners find doing practical work 'enjoyable' does not mean that learners will be thinking or learning about what they are doing, rather than the opportunity to have the freedom of something different in learning science. In such a case, a possible purpose to enhance scientific knowledge via practical work seems difficult to attain. This is especially true where doing is ineffective at enhancing students' understanding or learning of science

The study found that practical work does have an influence in teaching and learning of acids, bases and neutrals in Natural Sciences. Learners were able to explain what they saw or what they were doing during the practical work. They were of the perception that they understand the topic or subject being raised much better in practical rather than when they are just given explanations which sometimes are not clear for them to understand. Hence, practical lessons enable students to know scientific concepts.

5.4 Implications of the study

This study has implications for other science teachers, principals, curriculum advisors and the education department. It serves as an example of how through the absence of practical work learners achieve low scores in standardised tests. When the practical aspect of a topic like acids, bases and neutrals were implemented learners achieved much higher scores.

The schools need to invest more on practical work because it can increase students' sense of ownership of their learning and can increase their motivation. Also, knowledge cannot simply be transmitted directly from teacher to learner but, in science, that it requires the learner to get involved in their own learning and actively make sense of new information.

After visiting the primary schools situated in the area the researcher found that none of the schools have functional laboratories. Thus, the Department of Basic Education needs to invest in these schools by building laboratories so as to enhance the practical work. Also, investment is needed in the science kits for the learners to perform the practical work effectively.

Most of the teachers make no attempt at all to elaborate the curriculum by taking their learners out of the classroom and identifying the curriculum content where it is used in every day circumstances. Thus, to overcome this teacher need to be properly trained in Natural Sciences so that they become comfortable and positive about practical work. Using practical work as a teaching strategy will provide learners with an opportunity to learn curriculum content by exploring and being engaged in hands-on practical activities.

5.5 Limitations

The study was only focussing in grade 7 whereas the problem could be starting in lower grade. The results of this study cannot be generalised as only three schools were involved and limited to the topic acids, bases and neutrals.

5.6 Recommendations for future studies

Time constraints did not allow for the study to involve more schools and teachers in the study; hence a similar study could be done but with a larger sample in order to obtain a clearer idea of the factors that influence the use of practical work in the Natural Sciences.

5.7 Conclusion

The study established that practical work does have an influence in teaching and learning of acids, bases and neutrals in Natural Sciences. Learners were able to explain what they observe when doing the practical work. They demonstrated that they understand the topic or subject much better in practical work rather than when they are just given explanations which sometimes are not clear for them to understand. Hence, practical lessons enable students to understand scientific concepts better.

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7. Appendices

APPENDIX A: Observation Checklist

In the checklist below, mark the box which best reflects your observation of the teacher's practice. Where necessary make additional comments on your observation.

A. INTRODUCTION

Lesson Introduction

□ 1. No introduction, i.e. no connection is made with previous lesson.

No direction for new lesson. No greetings.

□ 2. Links with past lesson but no real focus for present lesson.

□ 3. Links with past lesson and clear focus for present lesson.

□ 4. Lesson is clearly contextualized and learners' interest is aroused.

Attention is focused. COMMENT (Was the lesson appropriately introduced?)

____

____

B. PRESENTATION and RESOURCES

B1. EXPLICIT ORGANISATION OF GROUP WORK

□ 1. No group work.

□ 2. Only two or three learners interact. Others just listen.

□ 3. Group of learners with limited interaction/interact when teacher motivates.

□ 4. Groups of pupils discuss problems, questions and activities by themselves. COMMENT (Does the organization relate to the type of lesson?) ____

____

B2. PUPIL-PUPIL INTERACTION WITHOUT TEACHER

□ 1. Pupils don't question each other or probe for details.

□ 2. Pupils question each other in secret because this is not allowed/ encouraged by the teacher.

□ 3. Pupils only question or help other pupils when prompted to do so by teacher.

□ 4. Pupils freely enter into discussions with each other. COMMENT (How is the frequency of interactions between pupils?):

____

____

B3. WHOLE CLASS TEACHER-PUPIL INTERACTION

□ 1. Totally controlled by the teacher.

□ 2. Mainly controlled by the teacher.

□ 3. Teacher creates opportunity for pupil-pupil interaction.

□ 4. Control of interaction shifts between pupils and teacher.

COMMENT (If no group work, what kind of pupil-pupil interaction is taking place, if any?) (Frequency):

____

____

B4. USE OF RESOURCES/MATERIALS/AIDS e.g. texts, chalkboard and notebooks

□ 1. No materials available for pupils or teacher to use.

□ 2. Only the teacher uses the materials in front while the learners are observing.

□ 3. Some learners use materials.

□ 4. Learners share and use materials.

COMMENT (Name materials used and frequency; if no materials used):

APPENDIX B: Observation Schedule

Dimensions (derived from literature)	Indicators	Occurrence (use tally)	Comments (on what is going on)
A: Learners' active involvement in lesson	1.Student-student Interaction		
	2.Teacher-student Interaction		
	3.Learner- initiated Questions		
B: Learners' experiences are used	1.Daily living References		
	2.Connections to other subject		
	3.Connections to prior math knowledge		
	4.References to indigenous situations		
C: Higher-order learning tasks are present	1.Problem solving (tasks)		
	2.Problem posing		
	3.Explanation by students (why?)		
	4.Investigations		
	5.Extensions of the Lesson		
	6.Projects (small)		

PRE-TEST

School: ______________________ Grade: ______________

1. Are acids edible? _______________________

2. How can you describe the taste of an acid?

   A Bitter B sweet C Sour D Salty

3. Give two examples of acids you know.

   _________________________ and __________________________

4. What do you understand about a base?

   ____

5. How can you describe water?

   A Acidic B Neutral C Basic D. Do not know

6. Is vinegar an acid, a base or neutral? __________________________

7. What is a scientific name for a vinegar? ________________________

8. Is soap an acid, a base or a neutral? __________________________

APPENDIX C: POST-TEST

Question 1

Use the words below to complete the following paragraph.

blue; bitter; rough; sour; indicator; red; slippery; corrosive; alkali; neutrals

Acids taste ______________and feel _____________on the skin. Strong acids can burn your skin. We say these acids are _____________. Bases taste ____________ and feel _____________. A base that can dissolve in water is called an ___________. An ____________ is a dye that changes colour in chemicals. Acids will turn blue litmus ______________ and bases will turn red litmus ________________.

Question 2

2.1 Give ONE examples of everyday materials that contain:

2.1 acid – :____________________________ 1

2.2 alkali – :____________________________ 1

3.1 Name two citrus fruits. : ___________________ and _________________ 2

3.2 Describe the taste of citrus fruit. : ____________________________ 1

3.3 Are citrus fruits acidic or basic? : ________________________ 1

3.4 Give the name of the acid or base that you find in citrus fruits.

____ 1

4. Red litmus indicator was used to test toothpaste. It turned blue. What does this tell you about the toothpaste? ___________________________________ 1

5. What colour would blue litmus paper be in these substances?

5.1 Fizzy drink : _______________________ 1

5.2 Water : _______________________ 1

5.3 Sugar solution : _______________________ 1

5.4 Soap : _______________________ 1

5.5 Orange juice : _______________________ 1

5.6 Bicarbonate of soda : _______________________ 1

5.7 Salt solution : _______________________ 1

APPENDIX D

EDUCATOR INTERVIEW SCHEDULE

EDUCATOR NAME: ……………………………………… GENDER: …………….

SCHOOL: ……………………………………………………………………………..

INTERVIEWEE: …………………………...………………DATE: ………………….

1. As part of formal assessment tasks in Natural Sciences you have to conduct practical work and investigations. How easy do you find these activities?
   1.1. What challenges if any do you encounter?
2. Do Natural Sciences teachers of the school perform practical work in all grades?
   2.1. How would you rate level of comfortability in lower grades?
3. Do you have science kit in your school that will be enough for all the grades?
   3.1. Is your science kit enough to enable you to let learners take part in practical work, not demonstration?
4. How often do you perform practical work in Natural Sciences?
5. Is practical work in your school done by all Natural Sciences educators in all grades?
   5.1. If not what measures do you have in your school to make sure that it is done by all?
6. How often do science educators of your school receive support in performing practical work?
   6.1. Who normally provides such support?
7. How can you describe the learner attitudes and reactions in Natural Sciences after we have done practical work?
8. Do you think science apparatus and material enhances pupil learning?
   8.1. If you do, in what way do you think these resources enhance learning?

9. Have you any other comments to make about the science apparatus and materials or training you received?

APPENDIX E

LEARNER INTERVIEW SCHEDULE

LEARNER NAME: ………………………………. GENDER: ……………. AGE: …….

SCHOOL: ……………………………………………………………………………..

INTERVIEWER: Richman Festile DATE: ………………….

1. What do you know about practical work?
2. In Natural Sciences do you do practical work.
   2.1. How often do you do them?
   2.2. Where do you conduct practical work?

3. What purpose do you think they serve to you as a learner?
4. During practical lesson does your teacher demonstrate or you as learners also do them yourselves?
5. Which form of practical work do you prefer to be used in your lesson? Teacher demonstration, group or individual?
   5.1. Explain why.
6. How did you accept the practical lesson by your teacher and teachers from science centre?
7. What can you tell me about how the lesson was conducted?
8. How different is that to normal lesson?
9. How do you think practical work influence your learning?

APPENDIX F

Example of interview with Teacher A

Researcher: My thesis is basically on the influence of practical work in teaching and learning of acids, bases and neutrals in Natural Sciences and I'm actually focusing in Grade 7. Okay? Focusing in Grade 7, trying to find solutions, so I'm going to ask you some few questions. I know there was a group of teachers from science centre, who actually did a practical for you in acid, bases and neutrals, so I've got few questions I'm going to ask you. And one more thing I want you to be free this is not a test, you're not going to pass or fail for answering it and I want you to be honest in answering it, in answering the questions. Uhmm, this is just between me and you, nobody will know how you answered here, it's just for me. In fact uhm, it's just writing names there just for my own references, otherwise in reporting this in my thesis. I will not say your name here that you answered you answered this, you have answered that, okay? Just be free, okay? And you can also express yourself in the language that you are comfortable on, let alone that I'm speaking in English, you can also say some terms you do not understand in the language you are comfortable with, hopefully not isiShona (laughs). Okay? Alright, the first question is: What do you understand about practical work?

Respondent: Okay, uhmm, practical work is like when you do like, it's when you do something like with your hands, uhmm you don't use like your brain to do the thing but you use your hands to fulfil that task that you thinking.

Researcher: Okay, thank you very much, now, uhmm in Natural Sciences, in your school, do you do practical work?

Respondent: Mhm, yes we do.

Researcher: How often would you say you do that? Would you say once a year? Once a quarter? Twice a quarter? How often? Once, everyday? Every week? How often would you rate your doing of practical work?

Respondent: I think it's going to be like, it would depend on the topic that we are like doing, like for example if we are doing something that has to do with the sun and the earth, it would be like everyday day because we need to like understand them so our teacher would do like practical work so that we will catch up fast, so like more often than we even can sometimes

Researcher: (laughs), alright, uhm. Where do you conduct it? Where is your teacher doing the practical works? Are you able to use some science equipment? Where would you do them?

Respondent: Mhmm, in our class, because like in our school we don't have like a lab so that we conduct tests or anything that will helps us to do.

Researcher: Okay, what purpose do you think uh, the practical works has, how does it help you if it does, if it actually retards your progress, how does it retard it?

Respondent: Okay, well uhmm, I wouldn't speak for myself as like a fast learner, but eish, okay. Like if I don't understand something, although I try to understand it but I still don't understand it that's when practical work like would like kick in and like make me understand something that I wasn't understanding on myself, so it helps me a lot.

Researcher: So during practical lessons, uhhm, does your teacher demonstrate or you as learners do practical work yourselves?

Respondent: Our teacher demonstrates the practical work, in return we show him what we understood from that, from all that practical work he has done we show him in return and he does it.

Researcher: How would you show?

Respondent: How would I show what?

Researcher: I mean that you understand, do you also get a chance to actually do some of the practical works on your own?

Respondent: Yeah we do, we do that like, when after maybe after he has explained and did the practical work, then he would ask us if we understood then we would reply yes. And if we reply yes he would ask maybe two or one of us to come and show him what we have learned as learners from what he was taught us.

Appendix G – Teacher Interview Schedule

Main Interview Questions

Introductory chatting will involve gathering a brief background of the teacher participant. This will include the following specific questions:

i. *How long have you been teaching science in high school?*

ii. *How long have you been involved in designing and conducting SBA activities?*

iii. *Where did you have your pre-service teaching education?* ....

0. (Introductory question) Can you tell me about the way you teach science?

1. What do you think is the main aim of teaching science?

(1b) What would be the main things you would like students to learn in your science classroom?

2. What are your views about the role of practical work in teaching and learning science?

(2b) What do you think are the learning outcomes of practical work in science?
(2c) What do you understand about the ways scientists work or scientific methods?

3. What are your views about the practical assessment activities in the SBA for SISC?

4. What do you think about the assessment schedules given in the SBA for SISC?

5. Can you talk about how you see the SBA activities assessing the science learnt by the students?

6. What sort of concerns do you have about the practical work and its assessment in the SBA for form 4 and form 5?

7. Can you talk about how best you would use practical work to assess students learning in science?

8. What changes would you like to see in the practical work in the SBA for SISC?