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Factors that influence the use of practical work in the Grade 10 physical sciences classroom

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CHAPTER 1 – Introduction and Overview

1.1. Background to the Study

The Concise Oxford Dictionary defines science as 'the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment' (South African Concise Oxford Dictionary 2005, p. 1047).

According to Chalmers (1982) scientific knowledge is proven knowledge. Scientific theories are derived in some rigorous way from the facts of experience acquired by observation and experiment. Science is based on what we can see, hear, touch, etc. Personal opinion or preferences and speculative imaginings have no place in science. Science is objective. Scientific knowledge is reliable knowledge because it is objectively proven knowledge.

The aims of science education might be summarised as:

- To help students to gain an understanding of as much of the established body of scientific knowledge as is appropriate to their needs, interests and capacities;
- To develop students' understanding of the methods by which this knowledge has been gained and our grounds for confidence in it (Millar, 2004, p.1).

As laid out in the Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011a), teaching science in the school curriculum includes an understanding of how scientific enquiry is conducted, of the different kinds of knowledge claims that scientists make, of the forms of reasoning that scientists use to link data and explanations and of the role of the scientific community in checking and scrutinising knowledge claims. CAPS also emphasises the integration of practical work with classroom science teaching. Learners are expected to be able to conduct experiments, carry out investigations and do projects as part of their assessment. Learners are therefore allowed to carry out their own scientific enquiries and thus acquire scientific knowledge for themselves in the science classroom. An enquiry based approach may encourage learners to be more independent and self-reliant and 'make learners aware of their environment and to equip learners with investigative skills' (DBE, 2011a, p. 8). In this regard, practical work in the science classroom has a central role to play.

Much of scientific knowledge we teach in school science is consensually agreed and beyond reasonable dispute.

> Scientific knowledge provides explanations for the behaviour of the material world. Through its methods of enquiry and procedures for testing and scrutinising knowledge claims, the scientific community has built up a body of knowledge which is consensually accepted by that community.
>
> Millar (2004, p.1)

Science teaching in schools involves the transfer of the knowledge by the teacher to the learner. This is called the transmission method of teaching. This method of transmission does not work when teaching of abstract ideas is involved. The learner must play an active role in taking on new knowledge. The learner has to 'make sense' of the experience and discourse of the science class and use it to construct meaning. The subject matter of science is the material world. It seems natural that learning science involves seeing, handling and manipulating real objects and materials and that teaching science should involve showing as well as telling. This is expanded on in Chapter 2.

In the South African context, science in the school curriculum comprises life sciences and physical sciences. This study focused on the physical science component of the school science curriculum. Physical Sciences investigate the physical and chemical phenomena. This is done through scientific enquiry, application of scientific models and laws in order to predict and explain events in the physical environment. The purpose of Physical Sciences is to make learners aware of their environment and to equip them with investigating skills relating to physical and chemical phenomena. Physical Sciences promote knowledge and skills in scientific enquiry and problem solving; the construction and application of scientific and technological knowledge; an understanding of the nature of science and its relation to technology, society and the environment (DBE, 2011a, p.8).

The school science curriculum in most countries has two distinct purposes, the first being to provide every young person with sufficient understanding of science to participate confidently and effectively in the modern world. Modern society needs some understanding of the nature of scientific knowledge in order to evaluate claims that may affect their everyday decisions and to reach informed views of public policy. Secondly, is to provide the foundations for more advanced study in science (Millar, 2004, p.1)

Learning science therefore has benefits for the country's sustained development and is therefore a worthy part of the Nation's school curriculum. The Physical Sciences plays an increasingly important role in the lives of all South Africans due to its influence on the scientific and technological development which underpins our country's economic growth and social well-being of our community. The application of Physical Sciences knowledge has

a profound impact on world-wide issues and events such as economic, environmental, social, political, ethical and technological (DoE, 2003, p. 9).

An understanding of science will enhance the participation of citizens when they are called upon to exercise their rights deciding on and responding to the directions of science and technology. The South African legacy has resulted in limited access to scientific knowledge and devaluing of indigenous scientific knowledge in certain sectors of the community due to the poor quality or lack of education (DoE, 2003). The study of Physical Sciences is aimed at correcting these historical limitations by contributing towards the holistic development of learners by:

- Giving learners the ability to work in scientific ways,
- Stimulating their curiosity, deepening their interest in the natural and physical world in which they live,
- Developing useful skills and attitudes that will prepare learners for various situations in life such as employment and entrepreneurial skills,
- Enhancing understanding that the technological applications of the Physical Sciences should be used responsibly towards social, human, environmental and economic development both in South Africa and globally. (DoE, 2003, p. 3)

1.2 Performance in Physical Sciences in South African Schools

The performance of learners in mathematics and science subjects in South African schools is a serious concern. The Trends in International Mathematics and Science Study (TIMSS) 1995, the largest most comprehensive and rigorous international comparison of education ever taken is highly significant in the context of mathematics and science education in South Africa (Howie, 2003). It has provided baseline information and a benchmark for future developments in mathematics and science education at national level. The TIMSS analysis of the mathematics results provided a common performance scale for all 41 participating countries. These results showed that the overall performance of South African Grade 7 and 8 learners, with an average score of 351, was far below the international average of 513. In another survey, the Joint International UNESCO-UNICEF Monitoring Learning Achievement Project revealed that South African Grade 4 learners scored an average of only 30 percent for numeracy, with a large proportion of them scoring less than 25 per cent. The Trends in International Mathematics and Science Study Repeat (TIMSS-R) (1999) showed that South African Grade 8 learners performed poorly compared to those of other countries. The South African average score of 275 was significantly below the international average of

487, lower than the results of the two other competing African countries, Morocco and Tunisia. These international studies show clearly that South Africa's learners are underachieving in numeracy, mathematics and science.

The Trends in International Mathematics and Science Studies (TIMSS) for 1995 and 1999 therefore serve as evidence of poor trends in learner performance in science in South Africa (Reddy, 2006). Locally however, the analysis of the 2011 Matriculation Examination results by the Portfolio Committee on Basic Education (2012) has indicated the poor performance of learners in Mathematics and Physical Science. Of the 180 585 learners that wrote Physical Sciences in 2011, 96 441 achieved 30% and above while 61 109 candidates achieved 40% and above. In 2012, the number of passes in Physical Sciences was 109918 which were 13477 more than 2011. The pass rate in Physical Sciences in 2012 was 61, 3%. The number of passes in Physical Sciences in 2013 was 124206 which were 14288 more than 2012. The pass rate in Physical Sciences in 2013 was 67, 4%. Although these results show an increase in the pass rate in Physical Sciences, there is still much more room for improvement.

1.2.1 Reasons for poor performance

Teacher competence

Makgato (2007) study in the Tswane North District 3 secondary schools in the Soshanguve Township investigated the poor performance of learners in Physical Sciences and Mathematics. The research findings suggest several factors that contribute to the poor performance of learners in both Physical Sciences and Mathematics. The factors include:

> …the lack of adequate practical experiments in the laboratories, the lack of teacher knowledge in Physical Sciences and Mathematics, inadequate parent involvement, lack of proper teaching and learning methods in Physical Sciences and Mathematics and the lack of motivation and interest of teachers and learners in the subjects.
>
> Makgato (2007, p. 100)

Haambokoma (2004) noted that adequate teacher subject matter knowledge was a key to learner's performance. Ajaja (2009) surveyed 90 senior secondary schools in the Delta State 2 in Nigeria. The finding that contributed to the poor performance of science teaching was that very few teachers were qualified and not competent as teachers because of the poor training they received as science teachers. The level of science teaching in the classroom depends on the quality of the training received by science teachers. Poor teacher training could account for the low teacher performance in the teaching of science where there is no

use of practical work but over reliance on the use of textbooks for teaching science (Ajaja, 2009, p.128). Kriek and Basson (2008) have noted that,

> ….. teachers with diploma qualifications were relatively more concerned about training workshops and practical work than teachers with degree qualifications. They felt that they were not adequately trained and that all the changes in the curriculum impacted negatively on teaching. (Kriek & Basson, 2008, p. 64)

Yet as Ogunniyi (1996, p. 278) has also argued, no education system is higher than the level of the teacher.

Curriculum Change

The curriculum in South Africa has undergone several changes since the 1994 democratic elections. The curriculum has change from the Nated 550 curriculum that was in operation prior to 1994 to the OBE curriculum, RNCS, NCS to the current CAPS. These changes in curriculum could have contributed to the poor performance of learners as these changes in the curriculum needed to be understood by teachers in order for proper implementation to occur. Mere and Kwayisi (2009) note that teachers were supposed to teach using OBE methods but it was evident that their knowledge on this principle was limited. The educators indicated that they needed support in order to implement the NCS. This indicates that the change of curriculum and its implementation can have an effect on the performance of both teachers and learners in the classroom. Kriek and Basson (2008) noted that there is too much content in the new curriculum. Teachers involved in the study commented that they do not have experience in teaching the new content and that the content was too difficult and too challenging for learners (Kriek & Basson, p. 69)

Incomplete Syllabus

Incomplete syllabus can contribute to the poor performance in Physical Sciences. Howie (2003) noted that there appeared to be insufficient time to finish the syllabus, as well as time being wasted in class with learners making noise, jokes and truancy. Ajaja (2009) found that a reasonable percentage of the content coverage of the science schemes of work was not covered. This was due to the frequent and protracted strikes of teachers.

Ramnarain and Fortus (2013), in their study to determine ‘South African Physical Sciences teachers’ perceptions of new content in a revised curriculum’ noted that teachers taught content on which the examinations were based due to content overload. There is not enough time to complete the Physical Sciences curriculum because the syllabus is too long and vast. Learners do not have time to apply what they have learned resulting in rote learning.

Language Barriers

According to Henderson and Wellington (1998, p.35), the greatest barrier to learning for many learners is language. The problem is that like many other African countries, South Africa teaches science in mainly English or Afrikaans. In the Eastern Cape, South Africa, according to The Education Foundation (1994, p. 130), 86% of people speak Xhosa and most likely study English as a second language. Thus the majority of learners may not comprehend what is written or taught and often resort to memorizing. Further, complications arise from the difference between the normal scientific English that demands clarity and the common English language usage (Muwanga-Zake, 1998, p.14). African Blacks suffer additional problems in that there could be no direct translation of concepts in vernacular (Muwanga-Zake, 1998). Several studies (Howie, 2003) have found that there is a relationship between mathematics achievements and learners proficiency in English. Thus the language barrier could account for the poor performance in both Mathematics and Physical Sciences (Prinsloo & Rogers, 2013) in South Africa.

1.2.2 Strategies to Improve the Performance of Learners

Steps taken by South African authorities to remedy the poor performance in mathematics, science and technology have resulted in the creation of the Ministry on Science, Technology and Culture which declared 1998 and 2000 years of Science and Technology (Muwanga-Zake, 1998). However, improving the quality of teaching and learning in mathematics, science and technology as a first step in rectifying this problem has now become a national priority (Makgato, 2007, p.90).

A targeted intervention approach has been implemented to deal specifically with mathematics and science at secondary school level. The Dinaledi Schools Programme, launched in 2001 was an attempt at increasing the performance of historically disadvantaged learners in Senior Certificate Mathematics and Physical Sciences in selected number of schools. The project had mixed results and only about one third of Dinaledi Schools had increased the numbers of learners that passed higher grade mathematics and science. In 2005 the number of schools in the initiative was increased from 102 to 400, but selection was based on stricter criteria and only those schools which achieve at least 35 mathematics passes in the National Senior Certificate examination among African children now qualify.

Efforts to improve school management exist. The Advanced Certificate in Education (ACE): School Leadership and Management was piloted in 2007 -2009 and designed for aspiring school principals as part of its wider strategy to improve educational standards. The ACE

delivered by South African universities has a strong practice based learning focus supported by classroom based content and several leadership development processes, notably mentoring, networking and site based assessment. The ACE evaluation showed a correlation between the ACE programme and improvement in learner performance (Zenex Foundation, 2013).

In addition, policy was introduced to improve accountability of schools against learning outcomes. In 2007 the government gazetted the Education Laws Amendment Act 31 of 2007 requiring the principals of any public school to submit annually to the provincial Head of Department, the following:

- A report showing the academic performance of the school,
- A plan setting out how the academic performance is to be improved over the following year, and
- A report by 30 June on progress made in achieving the plan.

(Zenex Foundation, 2013, p. 3)

While the foregoing including findings in Makgato (2007) study have revealed the many factors that lead to poor performance in the physical sciences at Grade 12 level as well as the steps by the government to stamp out the poor performance, Makgato (2007) study as well as the official report by Umalusi (DBE, 2012) have attributed the lack of practical work during the teaching of Physical Sciences as one of the factors that contribute to the poor performance in Physical Sciences.

1.3 Research questions

The CAPS document currently being implemented in Grade 10 Physical Sciences classrooms that places greater emphasis on the use of practical work during class teaching is in apparent response to the findings that have highlighted the lack of practical work in schools an important factor in the low learner outcomes in the sciences. The main concern of this study was to highlight the circumstances of successful the implementation of practical work in Physical Sciences classrooms.

In this study, the main question that has been addressed is: *What factors influence the implementation of practical work in the Grade 10 Physical Sciences classroom?* This main question has been investigated through seeking answers to the following specific research questions:

a) Do schools have the necessary resources to conduct practical work?

b) Have teachers been adequately trained to conduct practical work in their classrooms?

c) What other sources of support can be accessed by Physical Sciences teachers when doing practical work?

Answers to these research questions were to contribute to a better understanding of the needs of teachers and schools to implement practical work and hence meet the requirements of CAPS. This research was therefore to assist in the future planning by Department of Education Officials (Directors, Subject Facilitators, etc.) in order to provide support and assistance to schools. This research would encourage officials to conducts needs analysis of a school with the intention of improving the effective delivery of the science curriculum in particular schools guided by their specific needs. The rationale of the focus on implementation of practical work requirement in teaching of science is now discussed in detail.

1.4 Rationale of the focus on implementation of CAPS practical work requirement

As already mentioned, the CAPS document currently being implemented in Grade 10 Physical Sciences classrooms places greater emphasis on the use of practical work during class teaching; the details of the plan are now discussed as a means to highlighting the rationale of the focus of this study on the implementation.

Firstly practical work needs to be "integrated with theory to strengthen the concepts being taught" (DBE, 2011a, p. 11). The change in curriculum from the NCS to CAPS is an adjustment to what we teach and not how we teach (teaching method). The way the curriculum is written is now in content format rather than outcomes format, so it is more prone to the traditional teaching methods rather than OBE methods. The performance of learners in Mathematics and Physical Sciences can be improved by the use of various teaching methods. According to Usiskin (1997), teachers should be aware that learners need variety, so lecturing all the time, discussing all the time, or putting learners in groups all the time, will not be as effective and alternating these teaching methods is required. The use of appropriate teaching methods is crucial to facilitate learners 'understanding of Physical Sciences (Makgato, 2007, p. 97).

Secondly the Programme of Assessment for Physical Sciences is to include class tests, examinations and practical work assessment. Assessment is a continuous planned process of identifying, gathering and interpreting information about the performance of learners, using various forms of assessment. It involves four steps: generating and collecting evidence of

achievement; evaluating this evidence; recording the findings and using this information to understand and thereby assist the learner's development in order to improve the process of learning and teaching (DBE, 2011a, p.143).

Assessment should be both formal and informal. In both cases regular feedback should be provided to learners to enhance the learning experience. Assessment is a process that measures individual learners' attainment of knowledge (content, concepts and skills) in Physical Sciences by collecting, analysing and interpreting data and information obtained from this process to:

- Enable the teacher to make reliable judgments about a learner's progress
- Inform learners about their strengths, weaknesses and progress
- Assist teachers, parents and other stakeholders in making decisions about the learning process and the learners' progress.

(DBE, 2011a, p. 143)

In Grade 10, Physical Sciences teachers develop a year-long formal Programme of Assessment. The learner's performance in this Programme of Assessment will be used for promotion purposes.

Practical work in the Physical Sciences is to be used as an assessment tool. Learners are assessed formally and informally. Some of these practical activities form part of the formal assessment and others are done as part of the informal assessment.

Informal assessment tasks include homework, class work, practical investigations, experiments and informal tests. Formal assessment tasks include control tests, examinations, experiments and projects. Experiments refer to a set of outlined instructions for learners to follow in order to obtain results to verify established theory whereas practical investigations require learners to go through the scientific process (DBE, 2011a, p. 145).

All assessment tasks that make up a formal programme of assessment for the year are regarded as formal assessment. Formal assessment tasks are marked and formally recorded by the teacher for progression and certification purposes. All formal assessment is subject to moderation for the purposes of quality assurance and to ensure that appropriate standards are maintained.

Formal assessment provides teachers with a systematic way of evaluating how well learners are progressing in a grade and in Physical Sciences (DBE, 2011b, p. 3). Formal assessment form part of the year-long formal programme of assessment in each grade and subject.

Programme of Assessment in Grade 10

The learner's performance in the Programme of Assessment (Table 1.1) will be used for promotion purposes. The marks achieved in each of the assessment tasks that make up the Programme of Assessment must be reported to parents (DBE, 2011a, p. 147).

Table 1.1: Assessment Plan and weighting of tasks in the programme of assessment for Grade 10

TERM 1		**TERM 2**		**TERM 3**		**TERM 4**
Type of task	%	Type of task	%	Type of task	%	
Experiment	20	Experiment	20	Project	20	
Control Test	10	Mid-Year Examination	20	Control test	10	Final Examinations
Total	30		40		30	300
Final Mark = 25% Assessment Tasks + 75% Final Examination						

Source: DBE (2011a, p. 147)

The practical component of the programme of assessment contributes 25% of the final mark.

Practical assessment in Grade 10

In grade 10 learners will do two prescribed experiments for formal assessment and one project on either Physics or Chemistry in a year. A total of three formal assessments in practical work will be done. The formal assessment of learners which involves practical work contributes to the final mark in Physical Sciences. Further the mark determines whether the learner will progress to the next grade. As practical work does impact on the final results of learners in Physical Sciences, it is essential that schools can conduct both formal and informal assessments tasks effectively. Also in Grade 10 four experiments for informal assessment is recommended. This gives four informal assessments in practical work that needs to be done. A total of seven practical tasks need to be completed.

Practical investigations should focus on the practical aspects and the process skills required for scientific inquiry and problem solving. Assessment activities should be designed so that learners are assessed on their use of scientific inquiry skills, like planning, observing and gathering information, comprehending, synthesising, generalising, hypothesising and communicating results and conclusions (DBE, 2011a, p.144). Practical investigations should assess performance at different cognitive level and focus on process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts (DBE, 2011a, p. 144).

Schools that are not equipped adequately to conduct practical work will thus negatively impact on the assessment of learners. Table 1 indicates the percentage of marks allocated to experiments and projects which contributes to the final mark of the learners. The percentage of marks allocated to practical work makes a significant contribution of the assessment on learners in Physical Sciences. As the practical work component is to contribute to the learner's promotion mark; an investigation in to the capacity of schools to perform practical work was considered as a worthy undertaking in this study.

1.5 Chapter Summary and Structure of this Report

In this chapter I looked at the meaning of science and what the teaching of science entails, the performance of learners in the Physical Sciences, the reasons for their poor performance and the strategies employed by the Department of Education to improve the performance of learners in mathematics and science. The main research question and the specific research questions which guided the study and the rationale of the study and the impact that practical work in the science classroom has on the assessment and promotion of learners has also been discussed.

In Chapter 2, I conduct a literature review focusing on practical work, its role in teaching and learning, how practical work should be used, types of practical work, and the challenges in using practical work in teaching science. I also present this study's conceptual framework in this chapter.

In Chapter 3, I focus on the research design and the methods used to collect data i.e. teacher interviews and classroom observation. I also focus on the study context, the sample, the participants and the actual data collection sequence.

In Chapter 4, I analyse the data collected during the interview and classroom observation, present and discuss the findings of the study, while comparing the findings with existing studies.

In Chapter 5, I presented a summary of the findings of the research task. I also outline the overall significance of the study and make recommendations based on the findings. Implications for future and the limitations of the study are also considered. I conclude the chapter with personal reflections on the study.

CHAPTER 2 – Literature Review

2.1 Introduction

In this chapter I discuss practical work, the role of practical work in the science classroom, how practical work should be used, the different types of practical work, the challenges in using practical work, how practical work is used in South African science classrooms and the conceptual framework that was adopted as the basis of this study.

2.2 What is practical work?

Practical work has been defined in different ways in the literature by different authors. Millar (2004) refers to practical work as any teaching and learning activity which at some point involves the learners in observing or manipulating the objects or materials they are studying. Lunetta, Hofstein and Clough (2007, p.394) define practical work as "...learning experiences in which students interact with materials or with secondary source of data to understand the natural world". According to Tsai (2003, p. 847) practical work in school science means laboratory based experiences. This definition therefore requires that learners need to have access to laboratory facilities and equipment in order to develop their scientific process skills. Stoffels (2005) refers to practical work as those teaching and learning situations that offer learners opportunities to practice the process of investigations. He further indicates that practical work would involve hands-on and minds-on practical learning opportunities where learners practice and develop various process skills including "hypothesising, observation, interpreting, predicting, problem solving, communicating, and drawing and evaluating conclusions" (see also DBE, 2011a, p. 8). Thus one could define practical work as an activity in which concepts taught in the classroom are linked to real practise in the laboratory or the surrounding environment. Practical activities would therefore include the development of scientific process skills such as hypothesising, observation, predicting, etc.

2.3 What is the role of practical work?

The role of practical work in science teaching recorded in the literature includes "to encourage accurate observation and description, making phenomenon more real, arousing and maintaining interest and promoting a logical and reasoning method of thought" (Science Community Representing Education [SCORE], 2008, p. 5). In CAPS, practical work takes the form of simple practical demonstrations, experiments, investigations and projects. These activities are meant to develop skills in scientific inquiry and problem solving. Skills needed for practical investigations include "observation, data collection, analysis and drawing conclusions" (DBE, 2011a, p. 8).Practical work is also a means of increasing learners'

understanding of scientific concepts that may not be easily understood or abstract. It provides a means of developing scientific knowledge and skills. Practical work can also be offered with the purpose of "enhancing the mastery of subject matter" (Perkings-Gough, 2007, p. 93). Practical work is also used in the science class when students are unlikely to have observed the phenomenon we are interested in (Millar, 2004). In such a situation practical work is essential and irreplaceable.

Abraham and Saglam (2010) refer to an earlier work by Kerr (1963, p.27) that was an extensive study to investigate the nature and purpose of practical work in England and Wales. The study involved 151 schools and 701 teachers. The findings of the study revealed that teachers regarded the purpose of practical work were to:

- Encourage accurate observation and careful recording
- Promote simple, common sense, scientific methods of thought
- Develop manipulative skills
- Give training in problem solving
- Fit the requirements of practical examination regulations
- Elucidate the theoretical work so as to aid comprehension
- Verify facts and principles already taught
- Be an integral part of the process of finding facts by investigation and arriving at principles
- Arouse and maintain interest in the subject
- Make physical phenomena more real through actual experience.

Abraham and Saglam (2010, p. 755)

This summary suggests that practical work has the potential to contribute to meaningful learning in science. Harlen (1999) has identified the following three main purposes for practical work:

- Providing first-hand experience, so that pupils can 'see it for themselves' and in some cases do it themselves,
- Testing ideas by making predictions, setting up a valid test, collecting reliable evidence and relating what is found to the original idea. This practical work should be theory based.
- Experience of 'doing science' through carrying out an investigation which has a degree of open-endedness.

Harlen (1999, p.18)

Lunetta (1988) states that participating in appropriate laboratory and practical activities can play a very important role in developing scientific concepts and problem solving skills. Makgato (2007) found that the majority of schools in the sample did have poor resources for laboratory work. Science and mathematics are practical subjects whose teaching should link with the real world. According to Colin (1995), science is concerned with increasing learner's understanding of the natural world by observation and investigation through experiments. Ajaja (2009) noted that practical lessons are what make science real and remove it from abstraction. Practical lessons help to demonstrate concepts learned in theory. The failure of learners to excel in practical examinations was because of "the lack of basic skills for doing simple experiments in the sciences" (Ajaja, 2009, p.128). The lack of practical work in teaching science is due to the inability to provide well-equipped science laboratories.

Abrahams and Saglam (2010) discovered another aim of practical work in addition to those identified by Kerr (1963). In their research a sample of 301 schools were used to gather data. The instrument used to collect data was a questionnaire. The findings of the research revealed that with the changes in the curriculum, greater demand was placed on teachers to use practical work as part of the assessment of learners. Thus the purpose of practical work was to assess the performance of learners.

Practical activities were seen as the sole means of providing students with opportunities for processing information. The attributed outcomes of practical activities included a) reinforcement of the understanding of scientific concepts and principles, b) involvement in a number of handling and measuring skills and therefore the promotion of the development of practical skills and c) involvement in problem solving and a "thinking style" that exposed students to the way of "working like a scientist" (Lynch, 1986).

Attending laboratory sessions is important in learning physical science because practical work in a way brings to life what is explained in textbooks. By seeing educators demonstrating or conducting experiments themselves, learners supplement what is in textbooks and as a result learning is enhanced. An advantage of laboratory usage is that it helps improve learners' higher order learning skills such as analysis, problem solving and evaluating.

2.4 How should practical work be used?

From the foregoing practical work has the potential to contribute to meaningful learning in science (Hattingh, Aldous & Rogan, 2007). Millar (2004) noted that practical work is most likely to be most effective when learning objectives are clear and relatively few in number for

a given task. The task design should highlight the main objectives; stimulate the students thinking ahead so that the practical task is answering a question that the students are already thinking about. The task design should help students to make links between the science theory and what is observed.

Mere and Kwayisi (2009) state that in order to implement science teaching successfully, teachers need to have a good knowledge base of the subject as well as the use of different skills to pass knowledge to learners. In addition teachers must communicate effectively with learners; Sutton has argued convincingly in this regard in the words.

> …meaningful practical work, whether by scientists or by children, is always embedded in conversation, – a discussion of ideas that makes it necessary to check those ideas against experience. (Sutton, 1998, p. 174)

Tobin, Treagust and Fraser (1998) assert that exemplary science teachers maintain a favourable psychological learning environment in their classes and use an enquiry method as an integral part of their teaching. Hudson (2007) found in his study that high impact teaching of science can be achieved by teachers if they targeted misconceptions in their subject, were enthusiastic in their teaching, had practical scientific knowledge, clearly articulated objectives and included excursions to enhance science understanding. He noted that high impact science teaching may make a difference towards influencing students' positive long term memories about science and their science education.

The new emphasis in CAPS on the use of practical work in the teaching of the Physical Sciences is in stark contrast to the traditional 'cookbook' approach to practical work where learners followed 'recipes' for the execution of procedures handed down by the teacher without much thought or purpose (Anderson,2007). This investigative approach advocates greater learner autonomy (Ramnarain, 2011, p. 92).

Ramnarain (2011) notes that in South Africa, the lack of learner autonomy results in practical work being dominated by teacher demonstrations and a cookbook approach where learners merely follow the teacher's direction. Muwanga-Zake (1998) notes that textbooks used in South Africa do not outline the objectives of a practical exercise or the science processes which the practical ought to enhance. This relegates practical work to routine exercises that produce data for verifying textbook information and nothing else. Experiments hardly relate with the learner's environment and real life, and do not tease the learners intellectually or practically (Muwanga-Zake, 1998).

2.5 Types of practical work

Practical work in science can be put into three broad groups (SCORE, 2008) namely: core activities, directly related activities and complementary activities. While core activities include investigations, laboratory procedures and techniques and fieldwork, directly related activities include designing and planning investigations, conducting data analysis or analysing results, demonstrations, and experiencing phenomenon. Complementary activities include science related visits, surveys, presentation and role playing, group discussions and simulations.

CAPS focuses on four types of practical work i.e. demonstrations, experiments, investigations and projects described as follows: Demonstrations are those activities done by the teacher in order to help in explaining certain concepts. Experiments refer to a set of outlined instructions for learners to follow in order to obtains results and verify established theory. Practical investigations require learners to go through the scientific process. The scientific process requires learners to write down the aim of the investigation, formulate a hypothesis, identify the variables, design the experiment, observe and record data, analyse and interpret data and to write a conclusion. A project is an integrated task that focuses on process skills, critical thinking and scientific reasoning as well as strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts. This requires learners to follow the scientific method to produce a poster, a device, a model or conduct a practical investigation (DBE, 2011a, p. 144). I next discuss the use of practical work during teaching internationally as well as in the South African science classrooms. The practical work in science as defined by SCORE (2008), is similar to the practical work advocated by CAPS. While SCORE identifies three broad groups of practical work, CAPS identifies four types of practical activities, i.e. demonstrations, experiments, investigations and projects.

2.6 Challenges in using practical work in teaching science

2.6.1. International perspectives

Ajaja (2009) examines the activities which go on in the science classroom with the intention of comparing them with both the national and international standards of teaching science. The research question that guided his study was “How often are science practical lessons organised in our schools?” The research was conducted in the secondary schools in the Delta State, Nigeria. The research method that was used to collect data was a survey. The instrument used to collect the data was a questionnaire. The findings of the research indicated

that “the poor state of infrastructure, poorly trained teachers, large class sizes, lack of resources and very few qualified teachers” (Ajaja, 2007, p. 128) negatively influenced the teaching of science.

Abrahams and Millar (2008) conducted research on the effectiveness of practical work as a teaching and learning method in science. The research question that guided the study was: How effective is practical work in school science, as it is actually carried out as a teaching and learning strategy?

The study was conducted in eight state schools in the United Kingdom (UK) located in rural and urban areas. Data was recorded using field notes and tape recorded interviews with teachers and students. Field notes were taken in each lesson observed. Tape recorded interviews with teachers were carried out before and after the lessons in order to establish whether teaching objectives were attained. Conversations with students during and after the lessons were also recorded in order to gain insight into students thinking about the task which could not be obtained from observations alone.

The findings of the study suggest that ‘the apparent separation in teachers’ thinking and planning, of the teaching of substantive scientific knowledge and the procedures of scientific enquiry’ (Abrahams & Millar, 2008, p. 1964) contributes to the ineffectiveness of practical work. Evidence suggested that few practical lessons were designed to link observations made with the science content. The absence of this link reduced the effectiveness of the practical activity as a learning event.

Science Community Representing Education (SCORE) (2008), in the United Kingdom, identified several factors that impacted on the implementation of practical work in schools. Their findings in the research include the lack of equipment funding, lack of understanding of the aims of the changes in the science curriculum, the shortage of time and lack of resources for practical work, the lack of mentorships for inexperienced teachers in order to build confidence in practical work and the inadequate opportunities for training and professional development.

Gray (1999) has noted that the lack of adequate resources in developing countries greatly affects the quality of the delivery of the science curriculum. The provision of equipment and laboratories in the science curriculum is clearly central to the resource issue. The large majority of schools in the developing world are poorly equipped for hands on science or have no equipment at all.

In a study conducted in Indonesia (Thair & Treagust, 1999) to identify the constraints limiting the implementation of practical work, it was found that teachers experienced difficulties in areas of insufficient equipment, lack of preparation time and inadequate background knowledge in the subject area. Studies suggest the existence of four major constraints on the implementation of practical activities into physics teaching programs in Indonesian secondary schools. These are in

> ….areas of suitability, maintenance, and lack of sufficient equipment, the perceptions among teachers that practical skills are not examined and therefore should have a low priority in their teaching programs, and that the physics curriculum is overloaded with content, and the lack of sufficient preparation time which in part may be related to the lack of laboratory technicians support in schools.
>
> Thair and Treagust (1999, p. 367).

Thair and Treagust (1999) note that apart from the lack of resources in schools to conduct practical activities teachers are more oriented to preparing learners for examinations which is focussed on factual recall. This has also been reported in Kenya, where "preparing students to pass the mandated examinations is always foremost in the minds of the teachers; their priority is always given to completing the (wide) syllabi" (Oyoo, 2013, p. 463) at the expense of using practical work during teaching.

In research conducted on the effectiveness of science teaching in Kenya (Oyoo, 2013), it was noted that several factors impacted on the successful implementation of effective science education. Among these factors is the issue of teaching resources.

> It was noted that in many secondary schools, science laboratories, workshops and equipment are inadequate and the curriculum materials are in short supply. In some well-resourced schools teachers do very few science demonstrations and almost no classroom experiments which results in learners not attaining the skills necessary for learning science.
>
> Oyoo (2013, p. 465)

In many secondary schools, the number of students in a class is higher than a teacher can effectively handle, making it impossible for teachers to give individual attention. Large class sizes accompanied by the shortage of equipment make the development of scientific skills impossible (Oyoo, 2013, p. 461).

Yildiz, Akpinar, Aydogdu and Ergin (2006), conducted a study in Turkey to determine the science teachers' attitude towards aims of science experiments and to find out the variables that affect their attitudes. The research method used was a survey. A random sample of 87 science teachers was used. The study showed that the teachers regarded the most important

aims of experiments were "to help develop students' observational skills, and to ease learning" (Yildiz et al, 2006, p.3). The teachers considered experiments to improve student's manipulative and cognitive skills. It was noted that there was a significant difference between the teachers who have science laboratories and those who do not. Having no science laboratories or inadequate equipment in science laboratories in schools affect the teachers' attitude towards the aims of science experiments in a negative way. The teachers' opinion related to the non-existence of laboratories, and inadequate equipment in laboratories may divert the teachers from the idea of doing simple experiments even under the current skimpy circumstances (Yildiz, *et.al*. 2006). A South African teacher's survey indicates that teachers regard practical work as an important means of facilitating learning and understanding. The results obtained from the survey suggest that practical work is not used effectively to improve on the results of matriculants.

2.6.2. South African Perspectives

In South Africa, Makgato and Mji (2006) conducted a study to determine the factors that contribute to the poor performance in Mathematics and Physical Science. The study was conducted in District 3 of Tswane North. Participants were purposefully selected from seven schools with poor pass rates. Focussed group interviews were conducted with ten grade 11 learners from each school and one-on-one semi structured interviews were conducted with ten educators from the participating schools as a means to collect data. The findings of the study revealed that the factors that directly influenced the poor performance in Mathematics and Physical Science related to teaching strategies, content knowledge, motivation, laboratory usage and non-completion of syllabus.

Hattingh, Aldous and Rogan (2007, p. 84), focus on the implementation of the experimentation and problem solving approaches in science classrooms which is a requirement of the Science Curriculum Statement of Curriculum 2005. The main focus of the research was the use made of practical work in the teaching of Natural Science and the factors that influence the use of practical work in the science classroom. The main question that guided their research was: What is the relationship between capacity factors and practical work? The research was conducted in Secondary Schools in the Mpumalanga Province in South Africa. One hundred and seventeen (117) science teachers in 14-20 schools were involved in the research. The research method employed included surveys, case studies and classroom observations. The instrument used to conduct the research was a teacher questionnaire which was administered by the curriculum implementers in the nine districts of Mpumalanga, South Africa. The findings of the research highlighted a strong correlation

between capacity and practical work. High level of practical work was achieved when teachers collaborated with one another and across schools. In more functional schools where teachers and learners are in class at scheduled times, high levels of practical work was achieved. Teachers who perceive learners to be motivated and non-disruptive were more likely to engage learners in high levels types of practical work.

Using practical work during science teaching in South African Schools

Teacher Knowledge*:* Muwanga-Zake (1998), in a survey carried out during 1998 in the rural Grade 7-12 schools in the Eastern Cape, South Africa identified several problems that face science education in South Africa. Among these is the revelation that teachers do not use practical work in teaching because they are deficient in practical skills and do not understand science concepts. This view was also highlighted more recently in Stoffels (2005) where teachers were found not to conduct certain practical activities in Natural Science because of the lack of knowledge of the subject components of the Natural Sciences. For example, teachers who were more inclined towards Physics and Chemistry tended not to engage in practical activities that were related to the Biology part of the curriculum because of their lack of knowledge in Biology.

Motivation and interest of Physical Sciences teachers*:* According to Delvin (1997), current teaching strategies in Physical Sciences demotivate learners. He argues that such situations contribute to poor performance in mathematics and Physical Sciences. Hattingh *et al.* (2007), note that whether practical work will be conducted and/or the types of practical work that will be done depends on the teacher. Teachers who are motivated to do practical work will find ways to do so even in the most poorly resourced schools. Also, those who are not motivated will not do practical work even when they have access to the best of resources (Hattingh *et.al*, 2007). Muwanga-Zake (1998) found that there were attempts to use the science teaching equipment in only five of the 21 schools visited in his survey. In the remaining 16 schools, the equipment was found to be gathering dust or neatly stored in boxes that had never been opened.

Resources and Practical work*:* In the Eastern Cape, South Africa, Jennings and Everett (1996) found that only 23% of Black schools had laboratories. Of the 21 secondary schools surveyed, only 6 had science laboratories. Junior schools do not have laboratories and are overcrowded. MacDonald and Rogan (1988) argue that some school environments demotivate learning. School environments that can lead to a lack of interest in science include poor physical structures such as dilapidated buildings, lack of science equipment, libraries,

laboratories and basic services. A well-equipped laboratory would probably stimulate learners' interest and practical interest in science which could have an impact on the performance of learners in the sciences (Muwanga-Zake, 1998). Stoffels (2005) noted that the lack of resources in schools does not allow for teachers to conduct group practical tasks. Shortage of equipment does not permit group or individual practical activities. Teachers are forced to perform demonstrations in situations when there is a shortage of practical apparatus in the schools. The skills that the curriculum is intended to teach learners cannot therefore be achieved in the day to day teaching of science in under resourced schools.

Makgato (2007) found in his study in the Tshwane North District 3 secondary schools in the Soshanguve Township that the lack of practical experiments in schools contributed to the poor performance of learners in Physical Sciences. Schools that did not conduct experiments highlighted the lack of resources in schools as the contributing factor. It was noted that laboratories that are available at schools do not have equipment or the laboratories are used as rooms for storage of books.

In Mere and Kwayisi's (2009) study conducted in schools around the Mafikeng area in South Africa, it was revealed that the challenges that teachers encountered in the teaching of science included over-crowded classrooms and the lack of teaching and learning resources in schools. Schools in rural areas did have laboratories, but did not have electricity to facilitate practical work. Laboratories in urban areas were almost empty with only chairs and tables. Schools had no chemicals and very few apparatus.

The foregoing as presented in sub-sections 2.6.1 and 2.6.2 are indications of the problems that can be expected in the implementation of CAPS with regard to how science teachers use practical work during teaching in order to enhance learner understanding and conceptual development. This is the focus in this study.

2.7 Conceptual Framework

As already mentioned, CAPS encourages the use of practical work by stating that 'Practical work must be integrated with theory to strengthen concepts being taught' (DBE, 2011a). The use of practical work is based on the theory of constructivism. The key idea of constructivism is that knowledge of the outside world is viewed as human construction (Duit & Treagust, 1998). Learning occurs when learners actively construct or create their knowledge based on their experiences and existing knowledge. Learners have to make sense of the experiences and discourse in the science classroom and use it to construct meaning. Teachers' planned practical activities will allow learners to build on their previous knowledge and experiences

that will allow them to construct their own knowledge. Learners come to lessons with ideas about their world which already makes sense to them. Teaching needs to interact with these ideas, first by encouraging their declaration and then promoting consideration of whether other ideas make better sense (Chalmers, 1982). Piaget (1964) argues that we construct increasingly sophisticated and powerful representations of the world by acting on it in the light of our current understandings and modifying these in the light of the data this generates. Through action on the world, we generate sensory data which can either be assimilated into existing schemas or require that these be changed to accommodate the new data, in order to re-establish equilibrium between the internal and external realities. Through such action we construct a view of the objects that exist in the world, what they are made of and what can be made from them, what they can do and what can be done to them. Practical experience of observing and intervening in the world is essential for understanding (Millar, 2004, p. 8). Practical work therefore needs to involve a range of activities that a teacher plans to use to encourage and support students as they attempt to construct personal meaning (Millar, 2004).

2.8 Chapter Summary

In this chapter I focussed on practical work, how it should be used, types of practical work and the challenges in using practical work in science teaching both internationally and specific to South Africa have been presented. The conceptual framework as the rationale of the focus on practical work in this study has also been discussed. In the next chapter, I discuss the research design, data collection methods used in this research project; how the study was implemented is also discussed.

CHAPTER 3 - Research Design and Methodology

3.1 Introduction

In this chapter I focus on the research design, data collections methods and instrumentation used to collect data for this research project. I discuss the roles that a researcher can adopt when using observation as a method of collecting data. I also discuss the different types of interviews that can be used to collect data. I outline the context in which the study was conducted, the sample and the participants involved in the study. I then describe the steps followed in the data collection process. I conclude this chapter with an overview of the entire data collection process.

3.2 Research Approach

A case study research design was used in this research. A case study researcher observes the characteristics of an individual unit, a child, a clique, a class, a school or community. The purpose of such observation is to probe deeply and to analyse intensively the multifarious phenomenon that constitute the life cycle of the unit with a view of establishing generalisations about the wider population to which that unit belongs (Cohen, Manion & Morrison, 2002).

Case study research differs from experimental research in that the experimenter manipulates variables to explain cause and effect. Survey researches collect quantitative data using questionnaires or interviews and statistically analyse the data to describe trends about responses to questions and to test research questions or hypothesis (Creswell, 2012, p. 376).

In this case study two Physical Sciences educators from two ex-Model C schools were observed and interviewed. The main purpose of this case study was to indentify the factors that influence the implementation of practical work in their grade 10 Physical Sciences classrooms.

A case study was a suitable research design to use in this research project as only two educators and two schools made up the sample.

3.3 Data Collection Methods and Instrumentation

Using case study research design, data can be collected using several methods. In this study, use was made of observations and interviews.

3.3.1 Observation

*O*bservation is the process of gathering open ended first-hand information by observing people and places at a research site (Creswell, 2012). In this research study, permission was obtained from the selected institutions and selected teachers to observe the integration of practical work in teaching of Physical Sciences in Grade 10 classrooms. The advantage of using observation as a means of collecting data is that the researcher can record information as it occurs in the setting. The disadvantage of observations is that the researcher may be unfamiliar with the site and needs time to adjust to the environment.

Using observation as a method of gathering data requires the researcher to adopt an observational role. The three popular roles which a researcher can adopt are as a participant observer, a nonparticipant observer or a changing observational role.

Participant Observation: As a participant observer, the researcher takes part in the activities in the setting that is observed. The advantage of a participant observer is that it allows the researcher opportunities to see experiences from the participant's point of view. The disadvantage is that note taking cannot be done while the observer is engaged in the activities and needs to be done later (Creswell, 2012 p. 214).

Nonparticipant Observer: A nonparticipant observer does not get involved in the activities at the research site. The researcher observes the activities at the research site from a vantage point. Vantage point here means that the nonparticipant observer positions himself/herself at a place in the research site so that all the activities can be observed without interfering with the activities taking place at the research site.

Changing Observational Roles: An observer can also adopt a changing observational role. In this case the researcher adopts the role of a participant and at times adopts a role of a nonparticipant. The advantage of the changing observational role is that the researcher can engage in the activities thus experiencing the activities from the participants view point and also is able to observe the participants without being involved in the activities (Creswell, 2012, p. 215).

In this research study, I adopted the role of a nonparticipant observer. Adopting a non-participant role was to allow me to observe the activities in the classroom and to record data on the observation schedule as it occurred. Being a nonparticipant observer was to allow the teacher and learners to interact freely during the practical lesson. I was to be present in the classrooms during the Grade 10 Physical Sciences lessons and recorded field notes as data to be analysed later against the research questions. An observation schedule (Annexure A) as the research instrument was used to record the data at the site. The observation was designed so that details such as time, place, setting and the role adopted by the observer could be recorded. On the schedule provision was made for recording details of the infra-structure of the school. A table was used to record the activities of the teacher and learners during the observation of the practical lesson.

The observation schedule (Annexure A) was designed with the intention of collecting data that would provide answers to the research questions of this study. The observation schedule begins with noting the time, place, setting and observation role that the researcher adopts. Further to this provision is made for recording data related to the infrastructure and resources available at the schools. Information such as the availability of water, electricity, laboratory and laboratory equipment can be recorded on the observation schedule. On the observation schedule a table is provided for recording data from the classroom observation. The table was divided horizontally in one minute intervals for a total of forty minutes. The time allocated on the school time table for one a single lesson is forty minutes. If the practical lesson was longer than forty minutes a second observation schedule would be used to record the data. On the left vertical column of the observation schedule, items that needed to be observed during the practical lesson relating to the activities of the teacher and learners are listed. These items included the following:

- The teacher's explanations of learners needed to do in the practical task.
- The teacher's answers to the learner's questions.
- The teacher discussions of the results obtained in the practical activity.
- Whether learners gathered the apparatus to do practical work on their own.
- Learners' engagement on the practical work.
- Learners' involvement in the clearing away of the apparatus after the practical.
- Learners' discussions of the practical work outcomes in groups.
- Whether learners viewed a video on practical work.
- Learners' observation of a practical demonstration.

The researcher would then indicate the time spent on the different items by drawing a line next to the item that was observed indicating the time spent on a particular item. For example, if the teacher took five minutes to explain to the learners what needs to be done in the practical task, then the observer would draw a line next to the item completing the time period of five minutes. This would be done for the different items listed on the observation schedule for the duration of the practical lesson. In order to ensure reliability of the data collected, the observation schedule was designed so that it could be completed during the practical lesson.

3.3.2 Interviews

An interview survey is a form on which the researcher records answers supplied by the participants in the study. The researcher asks a question from an interview guide, listens for answers or observes behaviours and records responses on the survey (Creswell, 2012, p. 382). Interview surveys can be two forms: qualitative and quantitative. In qualitative interview surveys, the interviewer asks open ended questions and records the interviewee's responses. In quantitative interview survey, the interviewer uses a semi structured or structured interview guide consisting mainly of closed ended questions and provides response options to the interviewee. The interviewer records the responses of the interviewee to the questions (Opie, 2004).

The advantage of using interviews is the high response rate because individuals interviewed consent to the interview in advance. The interviewer is present to complete the interview. Interviewers are able to answer questions concerning both the purpose of the interview and any misunderstandings experienced by the interviewee. Interviewers can also conduct the interview at an appropriate speed. Oppenheim (1992, p. 81- 82) suggests that interviews have a higher response rate than questionnaires because respondents become more involved and hence motivated. It also allows more to be said about the research than is usually mentioned in a questionnaire. The disadvantage of the use of interviews is that it is prone to subjectivity and bias on the part of the interviewer. Interviews can be divided into three main types, structured, semi structured and unstructured interviews.

Structured interviews

Structured interviews are similar to questionnaires and "are often organised round a prearranged schedule of questions, which are short, direct and capable of immediate simple answers" (Opie, 2004, p. 117). Structured interviews display the following characteristics: the interview is controlled by the interviewer, the interview is less flexible, the interview is

guided by the researchers predetermined objectives and the responses to the structured interview allows for easy data analysis. The structured interview does not provide for respondents to elaborate on their responses. Lincoln and Guba (1985, p. 269) suggest that the structured interview is useful when the researcher is aware of what is not known and frames questions that will supply the required information.

Semi Structured Interviews

Semi structured interviews are more flexible than structured interviews in that this provide opportunities to probe and expand on the interviewees responses (Opie, 2004). The semi structured interview allows for changes in the prearranged format of the sequence of the questions as well as the change in wording of the questions. The semi structured interview is characterised by being more flexible, not completely predetermined and offers the interviewer less control over the course of the interview. The interviewer is able to probe and prompt in order to obtain more depth and detail to the answers given.

Unstructured Interviews

The unstructured interview "centres around a topic or topics predetermined by the interviewer" (Opie, 2004). Unstructured interviews maybe characterised by being very flexible, the direction of the interview can be unpredictable and may throw up unexpected findings. Unstructured interviews are useful when the researcher is not aware of what is not known and relies on respondents to provide the information.

In this research semi structured interview was used to collect data on the use of practical work in the Physical Sciences classroom. An interview schedule (Annexure B) was used to gather data during the interviews with the teachers. The types of questions that were used comprised both closed and open ended questions. The closed questions used on the interview schedule focussed on the personal details (e.g. Qualifications) of the teachers while open ended questions focussed on practical work and the implementation of CAPS. Open ended questions have the advantage of being flexible and allow the interviewer to probe responses given and to clear up any misunderstandings. Open ended questions can allow for unexpected or unanticipated responses and allows respondents to give answers as fully as possible.

The design of the interview schedule was guided by the research questions that needed to be answered during this research project. All questions listed in the interview schedule focussed on providing answers to the research questions. The interview schedule (Annexure B) consists of sixteen questions. The first two questions relate to the personal information of the

interviewee. Question three and four relate to CAPS training. Question five focuses on the aspect of assessment that forms part of the formal programme of assessment for learners. Questions six to twelve focus on the practical work that needs to be completed during the teaching of Physical Sciences in Grade 10. Question thirteen and fourteen, focus on the availability of resources at schools. Question fifteen focus on the time that is available to teach the Grade 10 Physical Sciences curriculum. Question sixteen focuses on the outside assistance that can be provided to teachers to assist teachers with the implementation of CAPS in the Grade 10 Physical Sciences classrooms.

3.4 Study Context, Sampling and Participants

3.4.1 Study Context

In South Africa, prior to the 1994 Democratic elections, education was administered separately and unequally to the different racial groups. The education of the four race groups at the time was managed by four separate Education Departments. African schools were the most disadvantaged and White schools were the most advantaged. This racial categorisation of schools provided an indication of difference in school curricular, infrastructure, qualification of teachers, management, governance of schools, educational culture and resource base of schools and socioeconomic status of learners (Dempster & Reddy, 2006). However, after the 1994 Democratic elections, the apartheid laws which outlawed integration of the races were abolished. This allowed for the racial integration of schools and communities. The new constitution that followed the Democratic elections gave rise to several changes in the school curriculum since 1994.

3.4.1.1 Curriculum Changes in South Africa

The South African school curriculum has undergone several changes since the democratic elections in 1994. The ambitions of that time have in many cases been rolled back in the face of financial and capacity constraints and policy has increasingly been refined in order to create better efficiencies and outcomes. The continuous policy revisions at curriculum level, have resulted in extreme challenges with implementation as policies are not given sufficient time to be embedded and adapted on the ground.

The new Outcomes Based Education (OBE) curriculum was introduced in 1997 to overcome the curricular divisions of the past. In the year 2000 problems experienced in the implementation of the outcomes based curriculum prompted a review. The Outcomes Based Education (OBE) curriculum was soon replaced by Curriculum 2005. The Curriculum 2005 was aimed at empowering teachers and was resource intensive, not very directive and

complex to implement in schools. This was reviewed and changes made to address its complexity. According to the Department of Basic Education the National Curriculum Statement (NCS) had four main concerns that motivated the changes:

- Complaints about the implementation of the NCS
- Overburdening of teachers with administration
- Different interpretations of the curriculum requirements
- Underperformance of learners (The Oxford Team, 2012,p. 2)

This led to the first curricular revision after democracy that led to: the revised National Curriculum Statement Grade R-9 and the National Curriculum Statements Grade 10-12.

The Revised National Curriculum Statement (RNCS) in general simplified the outcomes statements giving more emphasis to basic skills, content knowledge and grade progression. There was also an expressed importance given to supporting teachers. On-going implementation challenges resulted in another review in 2009. The review resulted in the Revised National Curriculum Statement Grades R-9 and the National Curriculum Statements Grades 10-12 to produce the Curriculum and Assessment Policy Statements (CAPS).

From 2012, the two National Curricular Statements for Grades R-9 and Grades 10-12 respectively are combined in a single document known as the Nationals Curriculum Statement Grades R-12. The National Curriculum Statements for Grades R-12 builds on the previous curriculum but also updates it and aims to produce clearer specifications of what is to be taught and learnt on a term by term basis. The National Curriculum Statement Grades R-12 represents a policy statement for learning and teaching in South African schools and comprises of the following:

1. Curriculum and Assessment Policy Statements (CAPS) for all approved subjects,
2. National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12
3. National Protocol for Assessment Grades R-12

DBE (2011a, p. 3)

The purpose for the change in the curriculum from the NCS to CAPS is to lessen the administrative load on teachers and to ensure that there is clear guidance and consistency for teachers when teaching (DBE, 2011a, p.7). The rationale for this has been provided in section 1.4.

The curriculum's aim is to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. The curriculum promotes knowledge in local context, while being sensitive to global imperatives (DBE, 2011a, p. 4). CAPS are a more regulated learning programme than previously and provide more time for languages and mathematics. Workbooks are a central feature of CAPS, leaving less responsibility on educators to do the interpretation of curriculum outcomes. In addition the workbooks pace and sequence work on a daily and term by term basis with easy to follow worksheets to improve listening, reading , writing and numeracy skills. The workbooks are distributed by the national Department of Basic Education rather than provinces, indicating an increased centralization over curriculum delivery.

With the introduction of CAPS, every subject in each grade has a single, comprehensive and concise policy document that provides details on what teachers need to teach and assess on a grade by grade and subject by subject basis. There are clearly delineated topics for each subject and recommendations on the number and type of assessments per term. In CAPS, outcomes and assessment standards of the NCS have been replaced by topics and themes. Learning areas are now called subjects (The Oxford Team, 2012, p. 5).

These changes in the curriculum and the requirements are always placed on educators and schools to implement. The implementation of the Grade 10 Physical Sciences in respect of practical work forms the basis of this study. I next describe the CAPS training provided educators as conducted with Grade 10 teachers/educators as a means to prepare them to successfully implement the practical work requirement in their teaching.

3.4.1.2 Training for implementation of CAPS in the Grade 10 Physical Sciences classrooms

The Department of Basic Education started the implementation of CAPS in 2012 in the Grade 10 Physical Sciences classroom. Educators received training in CAPS during the school October School Holidays in 2011. The training took place over 3 days i.e. 4rd to 6th of October from 8h00 to 15h00. The training took place at a school in Kempton Park on the East of Gauteng. Teachers where informed of the training via a circular sent to school (Annexure Q) and at cluster meetings.

The training was conducted by subject advisers and selected educators. Educators were divided into three classes of 35 to 40 per class. The programme for the training included the topics: General Overview of CAPS; Subject Statement vs. CAPS; Content Mapping; Planning; Methodology; Informal and formal Assessment; Program of Assessment; and Moderation.

The programme did not include any hands on experiments which could be done by teachers in order to give teachers practise in doing practical work that was prescribed by CAPS. The training was more focussed on the orientation of teachers towards CAPS rather than providing teachers with content associated with practical work experience which could then assist teachers in conducting practical work effectively when implementing CAPS. This, it was hoped, would also help teachers to use practical work to reinforce concepts that are taught in Physical Sciences. The training involved reading through the CAPS document with the intention of identifying changes that have been introduced compared to the NCS. The changes identified were the removal of the topic on geometric optics and the inclusion of new topics such as reactions in aqueous solutions and stoichiometry. Educators were also informed of the new assessment requirements of CAPS.

3.4.2 The Sample

This study was conducted in two ex-Model C secondary schools which were originally used to educate white learners during the apartheid era. Today, the schools are multiracial with both the learners and teaching staff belonging to the different race groups. The two participant schools are located on the East of Gauteng. School A is located in the suburb of Primrose, Germiston, while School B is located in Edenvale. Both schools are secondary schools with a school population in excess of a 1000 learners. These schools were selected as research sites because of their close proximity. School A is situated approximately one kilometre away from the school where I teach while school B is about 4 kilometres away. Both schools could therefore be reached in a very short period of time. The schools that were selected for research are schools which offered Physical Sciences at Grade 10 level. These schools were currently implementing the CAPS in Grade 10 and were therefore relevant sites to investigate the factors that influence the use of practical work in the teaching of Physical Sciences in Grade 10.

Prior to the 1994 democratic elections these schools were under the control of the White Education Department. These schools are built of brick and cement, were fully resourced, had fully functional laboratories, libraries, recreational facilities, assembly halls and administrative blocks and supplied with essential services such as electricity and water. Since 1994 these schools became open to all races and are currently multi-racial and both learners and staff at these schools belong to various racial groups which include Black, White, Indian and Coloured.

3.4.3 The Participants

The participant educators, drawn from this multicultural context, comprised two Physical Sciences educators that are currently teaching Grade 10 Physical Sciences in secondary schools in the Ekhuruleni North District in the East Rand in the province of Gauteng. The teachers selected were teachers who are implementing CAPS in Grade 10 and who had undergone the CAPS training in 2011. These teachers have therefore been trained to implement CAPS in 2012, and were able to provide relevant data on the implementation of practical work in the Physical Sciences classrooms. The names that I have used to refer to teachers are pseudonyms.

School A – Mr Jere: Mr Jere has been teaching Physical Sciences for 8 years. He has also completed a Master in Science Education at the University of the Witwatersrand. As the grade 10 Physical Sciences educator, he had attended the CAPS training in 2011 prior to the implementation of CAPS in Physical Sciences in Grade 10 in 2012. He was thus a suitable participant to be involved in this research project. Mr Jere has 47 learners in his Physical Sciences Grade 10 class. His school, school A is a modern school built from cement and bricks. It consists of an administration block, technical centre and a three storey block which has the classrooms and laboratories. The school is also has a huge sports field and assembly hall. The school is fully secured with a 1.8m fence which surrounds the school and access gates which are controlled by the administration staff. The school is provided with the basic supplies such as water and electricity. The school is fully staffed with administrative staff, teaching staff and ground staff who are responsible for the maintenance of the school buildings and school grounds. The school provides education for a multiracial group of learner, however over 90% of the learners are black.

School B – Mrs Hefer: Mrs Hefer, at the time of the study had 22 years of experience in teaching Physical Sciences. Her highest qualification was second year level of University Physics. Mrs Hefer was a Physical Science CAPS facilitator. She was involved in the training of Physical Science teachers for the implementation of CAPS in the Grade 10 Physical Science classrooms in 2012. Mrs Hefer has 25 learners in her Physical Sciences class. Her school is a school with an excess of a 1000 learners. The buildings are made from brick and cement. It consists of an administrative block; a technical centre and a three storey block which house the classrooms and laboratories. In addition to the brick and cement structures the school also has prefab classes to cater for the increase in enrolment of learners. The school has an assembly hall, sports field and swimming pool. The school is supplied with the basic services such as water and electricity. The school has an administrative staff, teaching

staff and ground staff for the upkeep and maintenance of the buildings and grounds. The school is well secured with fencing around the school and a controlled security gate provides access to the school. The school provides education for a multiracial group of learners. The educators had been approached at the seminar to consider participating in this study; the sample that was used was therefore a convenience sample. These two teachers agreed to participate after I explained to them the purpose of the research project, how confidentiality would be ensured and that they could withdraw from the study at any time should they find it necessary without any disadvantage.

3.5 Actual Data Collection

As so far described here, this study involved the use of observation and interviews as the methods of data collection. Observation is used as a method of data collection in order to get first-hand information about the use of practical work in the classroom as it occurs. An observation schedule was used to collect the data (Annexure A). An interview was used to obtain more useful information from participants that could not be obtained through observation. An interview schedule, which comprised of open and closed questions, was used for this purpose (Annexure B).

3.5.1 Accessing the Research Sites

3.5.1.1 Permission to conduct research in schools

This was done in steps. First, an application was made to the Gauteng Education Department for permission to conduct research in these two Gauteng Department of Education (GDE) secondary schools. This application was made on the 19 June 2012. A letter granting me permission to conduct research was emailed to me on the 8 October 2012 (Annexure L).

An application was made online to the University of the Witwatersrand Ethics Committee. The application was turned down on the first attempt citing ethical concerns. The ethical concerns involved the information letter and the consent form. I was advised to address the following points:

Information Letter

- The length of time each of the research instruments are expected to take.
- The amount of time after which the data will be destroyed.
- Saying that the participants can withdraw without any disadvantage.

Consent Form

- To provide the option for participants not to agree to participate.
- State what kind of participation they are consenting to.
- Provide a learner and parent consent form for learners that are under 18 years.

Instrumentation

- Reduce the length of the interview.
- Provide an observation schedule.

After addressing the points raised by the University of Witwatersrand Ethics Committee, clearance was granted on the 5 March 2013 (Annexure M).

I approached the Principal of School A to request permission to conduct research at his school. The Principal was explained the purpose of the research project and was presented with a Participant Information Sheet (Annexure C), Letter to the Principal (Annexure D) and a Principal's Consent Form (Annexure E). He was willing to allow me to conduct research at his school.

The Principal of school B was approached by Mrs Hefer. Mrs Hefer is a Head of Department and a member of the School Management Team assisted me in this regard as the Principal was not available after school hours. She was given the Participant Information Sheet (Annexure C), Letter to the Principal (Annexure D) and the Principal's Consent Form (Annexure E) which was presented to and completed by the Principal.

The Principals of both schools were also presented with a copy of the GDE Research Approval Letter (Annexure L) which granted me permission to conduct research in these two schools. The Principals were assured that my presence in the school would not disrupt the daily programs of the school. Both gave me their written consent to conduct the study at their schools.

3.5.1.2 Invitation of Participants

After gaining the consent of the principals, the targeted educators were formally invited to participate in the study by means of a Participant Information Sheet (Appendix C). The Participant Information Sheet explained to the participant the importance of the study, the purpose of the study and assured the potential participant educators of their right to anonymity and confidentiality during their participation in the study. The participant

educators were also informed that they could withdraw from the study at any time should they find that necessary without any disadvantage. On consenting to participate in the study, the principals and teachers were requested to sign consent forms (Annexure D & E).

3.5.1.3 Permission to conduct research in the classroom

Mr Jere: I approached Mr Jere from school A for permission to conduct research in his Grade 10 Physical Sciences classroom at a cluster meeting for Physical Sciences teachers. He agreed after I explained to him the purpose of the research project. I gave him a Participant Information Sheet (Annexure C), Letter to the Teacher (Annexure F) and the Teacher Consent Form (Annexure G). I subsequently contacted him telephonically to arrange for the time that I could visit in order to do data collection. He forwarded the dates and times to me via a learner from the school. I sent him the Participant Information Sheet, Letter to the Parent (Annexure H), Parent Consent Forms (Annexure I), Letter to the Learner (Annexure J) and Learner Consent Form (Annexure K) for the learners in his Physical Sciences Grade 10 class via a school learner. Mr Jere explained to the learners the purpose of the study and handed out to them all the necessary forms that needed to be completed by the learners and their parents. Mr Jere subsequently collected all the consent forms from the learners in his class and handed them over to me.

Mrs Hefer: I approached Mrs Hefer at her school, School B, after school hours. I explained to her the purpose of the research project. She was willing to participate in the research project. I gave her the Participant Information Sheet (Annexure C) and Letter to the Teacher (Annexure F) and the Teacher Consent Form (Annexure G). I subsequently sent her, the Letter to the Parent (Annexure F), Letter to the Learners (Annexure J), Parent Consent Forms (Annexure I) and Learner Consent Forms (Annexure K) for the learners in her class. Mrs Hefer explained to the learners the purpose of the study and provided them with the forms that needed to be completed by the learners and their parents. The parents of the minors among the learner participants were sent Participant Information Sheet (Annexure C), Letter to Parent (Annexure F) and Learner Consent Forms (Annexure K) to give permission for their children who were under 16 years of age to be involved in the study.

3.6 Actual Data Collection Process

3.6.1 Data Collection at School A

I arrived at the school fifteen minutes before the schedule time. I waited in the school foyer while the receptionist used the intercom to call for Mr Jere. Mr Jere asked me to wait until the next period when the Physical Science Grade 10 learners would be in the laboratory. At the

end of the period Mr Jere came to the foyer to take me to the laboratory to conduct the observation. At the science laboratory, I was introduced to the learners by Mr Jere. I greeted the learners and explained to the learners the purpose of my visit and encouraged the learners not to be intimidated by my presence and to conduct themselves normally as if I was not present. I occupied a seat at the back of the class. I adopted the role of a nonparticipant observer. The place that I occupied allowed me to observe the class as the teacher and learners engaged with each other during the practical lesson. This practical was on the heating curve of water which is one of the prescribed experiments for CAPS in Grade 10. Learners are to be assessed on this experiment.

The observation was conducted with the aid of an observation schedule (Annexure A). I completed the observation schedule noting points on the availability of services such as water and electricity, availability of laboratory equipment, size of the laboratory as well as the interaction between the learners and the teacher. I made notes as I observed the activities in the class in order to avoid inaccuracy in the data. The observation was concluded at the end of the practical lesson. The teachers and learners were comfortable with my presence in the laboratory as they were explained the purpose for me being there. I interviewed Mr Jere after he had conducted the practical lesson with his class. The interview took place in the science laboratory immediately after the practical lesson in Mr Jere's free period. The laboratory was not in use at this time and provided a quiet place in which to conduct the interview. The pace of the interview allowed the interviewee ample time to respond to the questions asked, for example Question 16 (Annexure B) on the interview schedule required the interviewee to think of a response in order to answer the question. In this case sufficient time was allowed for a response to be given.

Recording of responses took the form of hand written notes. I ensured that the interviewee were comfortable during the interview so that responses to the questions would be accurate as possible (Creswell, 2012, p. 400). At the end of the interview, I thanked the interviewees for his participation in the interview and answered the queries and concerns relating to the research that the interviewee might have had. For example, Mr Jere wanted to know how many other schools were involved in the study. After the interview, I explained the next steps of the research.

3.6.2 Data Collection at School B

Same as in School A, I arrived at School B about fifteen minutes before the scheduled time. I went to the school foyer where I was received by the school receptionist. The receptionist

directed me to the laboratory where Mrs Hefer was situated. I waited outside of her class as she was still busy with her lesson. When the period ended I greeted her and she welcomed me to her laboratory. I thanked her for granting me permission to conduct research in her laboratory. I then reminded her about the purpose of the research project. I explained to her the steps that I will follow in order to collect data. As she had a free period before her double period practical lesson, she suggested that it would be convenient to conduct the interview during this free period while she was busy with the preparation for the practical lesson. Before I started with the interview I described to Mrs Hefer the instrument that would be used for the interview and the recording of the responses to the questions. The pace of the interview allowed the interviewees ample time to respond to the questions asked. Recording of responses had taken the form of hand written notes. I ensured that the interviewees were comfortable during the interview so that responses to the questions would be accurate as possible (Creswell, 2012, p. 400). At the end of the interview, I thanked the interviewee for her participation in the interview and answered any queries or concerns relating to the research that the interviewee might have had. After the interview, I explained the next steps of the research.

After the interview was completed, I observed the Grade 10 Physical Sciences class in the Physical Science laboratory. I was introduced to the class by Mrs Hefer. I greeted the learners and explained to the learners the purpose of my visit and encouraged the learners not to be intimidated by my presence and to conduct themselves normally as if I was not present. I positioned myself in the laboratory in order to get the best position to observe the practical lesson. I adopted the role of a nonparticipant observer. The practical lesson was on the cooling curve of water. This experiment was one of the prescribed experiments to be conducted by Grade 10 Physical Science learners. The experiment was done in order to fulfil the assessment requirements of CAPS.

Field notes were recorded on an observation schedule (Annexure A). I completed the observation schedule noting points on the availability of services such as water and electricity, availability of laboratory equipment, size of the laboratory as well as the interaction between the learners and the teacher. I made notes as I observed the activities in the class in order to avoid inaccuracy in the data. The observation was concluded at the end of the practical lesson. The teachers and learners were comfortable with my presence in the laboratory as they were explained the purpose of my presence for being there. At the end of each lesson, I thanked the participants and informed them of the use of the data and the availability of the findings of the research after the study was complete.

3.7 Review of data collection: observations on entering and exiting the research site

The order of data collection in School A and School B would not affect the outcome of the research project, as the interview was not focussed on a particular practical task under observation, but rather on observing how practical work is conducted in school generally. The interview was focussed on the general use of practical work in teaching science in school and not on a specific practical task. The order of the observations and interview will have no effect on the outcome of the research project.

Gaining access to the school was made possible as the Participant Information Sheet (Annexure C), Letter to the Principal (Annexure D) and the GDE Research Approval Letter (Annexure L) was presented to the school Principals. The research conducted at the participating schools was easier as the participating teachers were colleagues of mine and whom I had associated with at the various Physical Sciences workshops and cluster meetings. Their cooperation and willingness to assist me in this research project made it possible for me to gain access to the school, their science laboratories and their Grade 10 Physical Sciences learners.

The learners in the Physical Sciences classes and their parents were provided with Participant Information Sheets (Annexure C), Letter to Learners (Annexure J) and Letter to the Parent (Annexure H) which explained the purpose of the study. The learners thus understood the reason for my presence in the laboratory during the practical lesson and were very cooperative during my observation of the practical lesson.

As both teachers and learners were very cooperative during my research project, I did not experience any challenges that could impact on the findings of this study. After data collection I thanked the teachers and learners for the allowing me to conduct the research survey. I also informed them that the findings of the research would be made available to them if it was required.

3.8 Chapter Summary

In this chapter I have discuss the overall research approach, data collection methods and instruments used to collect data. I have also discussed the study context, the sample, participants and the procedures that where followed in order to access the research site and to do data collection. In the next chapter I focus on the analysis of the data collected through the interviews and classroom observations.

CHAPTER 4 – Findings and Discussions

4.1 Introduction

The research project was conducted in response to the introduction of the new CAPS curriculum in Grade 10 Physical Sciences in 2012. 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. Teachers are expected to teach the content of the Physical Sciences by incorporating practical work in their lessons in the form of demonstrations, experiments and/or investigations in order to strengthen the concepts that are being taught. This is within the aim of Physical Sciences to make learners aware of their environment and to equip learners with investigating skills relating to the physical and chemical phenomenon (DBE, 2011, p. 8). To reiterate Physical Sciences aims to develop skills such as classifying, communication, measuring, designing an investigation, drawing and evaluating conclusions, hypothesising, identifying and controlling variables, observing, comparing and interpreting and problem solving (DBE, 2011a, p.8).

Physical Sciences also prepare learners for future learning, specialist learning, employment, citizenship, holistic development, socio economic development and environmental management. Physical Sciences play an increasingly important role in the lives of all South African owing to their influence on scientific and technological development, which are necessary for the country's economic growth and the social wellbeing of its people. Incorporating practical work will enhance the learning of this very important subject.

In this chapter I focus on the analysis of data collected from the teacher interviews and classroom observations of the Physical Sciences practical lessons. I then discuss the findings of the study and also compare the findings with existing studies.

To reiterate, the main research question that was being addressed in this research project was *"What factors influence the implementation of practical work in the Grade 10 Physical Sciences classrooms?"* This main research question was investigated by seeking answers to the following specific research questions:

a) Do schools have the necessary resources to conduct practical work?

b) Have teachers been adequately trained to conduct practical work in their classrooms?

c) What other sources of support can be accessed by Physical Sciences teachers when doing practical work?

The research design, methods of data collection and the instrumentation used in this research project as well as the implementation of the study have been laid out in Chapter 3. The analysis of the data obtained through the observation of the practical lesson and the interview of the two Physical Sciences teachers was done using an interpretative approach but with reference to the research questions. In the next paragraphs I present and discuss the findings from the classroom observations and interviews in School A and School B with Mr Jere and Mrs Hefer respectively.

4.2 Findings from observations of Practical Lessons

As so far mentioned the practical lesson observed in both schools was a prescribed practical activity for formal assessment. This prescribed activity was an experiment in chemistry: Heating and cooling curve of water. This experiment can be done in two parts. Learners can determine the heating or cooling curve of water. Depending on the time available learners can determine both the heating and cooling curve of water.

4.2.1 Mr Jere's lesson at School A

In school A the teacher, Mr Jere conducted the experiment in the science laboratory. The science laboratory consisted of a teacher's desk, eight laboratory desks for the learners, a store room, storage cupboards along the wall and a fume cupboard. The laboratory desk and teacher's desk was not supplied with gas, electricity and water (Annexure R).

Mr Jere arranged the learners into four groups of about 12 learners each. Due to the large class size (47 learners), the groups were large. The learners conducted the experiment to determine the heating curve of water. As the laboratory was not fully equipped and supplied with electricity and water, the educator had to obtain boiling water and ice from the school staffroom. The groups were provided with a beaker, thermometer, ice and boiling water. The learners in the group divided the tasks among themselves. The tasks the learners engaged in during the experiment were time keeping using a stop watch, data recording, reading the temperature on the thermometer and stirring the water in the beaker. The teacher supervised the learners in their groups as he walked around from group to group. He guided the learners as they conducted the experiment. As the groups were large due to the lack of laboratory equipment to do the experiment, not all learners were fully involved in the experiment and thus depended on the other learners in the group to provide them with the data which they needed in order to draw the heating curve of water. The experiment was conducted over a single period. 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. More

time was required for the learners to obtain a complete set of results which they could use to draw the heating curve of water.

The pre-practical lesson had been done by the teacher in a previous lesson. This preplanning allowed the learners to get involved immediately in the practical experiment as soon as they entered the laboratory as the teacher had already explained to the learners what was required of them when conducting the experiment. The pre-practical lesson made learners aware of what was required of them during the experiment and allowed them to be on task in the shortest possible time.

Effectiveness of Practical Work in School A

The practical work conducted was affected by several factors. The large class size did not allow for the formation of groups of manageable sizes. The group of 12 learners per group was too large for all learners in the group to be directly involved in the experiment. Learners were therefore unable to acquire skills as required by Physical Sciences.

The lack of adequate supply of equipment such as thermometers, etc. did not allow for groups to be made smaller, The shortage of equipment resulted in groups being too large thus preventing each learner in the group from being fully involved in the experiment.

The single period used (35 minutes) to conduct the experiment was not adequate for the learners to complete the experiment and the write up for the experiment. The experiment would have been completed successfully if the teacher used a double period to conduct the experiment.

4.2.2 Mrs Hefer's lesson at School B

In School B Mrs Hefer also conducted the prescribed experiment in the science laboratory. The science laboratory at this school is divided into three parts. The first part, in front of the laboratory consisted of the teacher's desk and six laboratory desks. The laboratory desks were used for lessons and for learners to do written work. The middle part of the laboratory has eight practical work stations were learners conducted their practical work. Behind the work stations was the third part of the laboratory which comprised of the fume cupboard and storage cupboards. The laboratory was supplied with electricity, gas and water.

The experiment that was conducted was the cooling curve of water. At the beginning of the practical lesson the learners sat at their desks in the front of the laboratory. Mrs Hefer then reminded the learners of what was expected of them when conducting the experiment. After a

short reminder the learners went to the laboratory benches in their groups to conduct the experiment. The class was divided in to six groups, each of 3-4 learners. Each desk was provided with a thermometer, a stopwatch, beakers and test tubes. Learners conducted the experiment on their own with very little assistance from the educator. Learners divided the tasks such as time keeping, data recording taking of readings and stirring of the beaker among them. Due to the small groups some learners had to multi-task e.g. stir the water and take the thermometer readings. The practical lesson was conducted over a double period. At the end of the first period most of the groups had completed the experiment. The availability of water in the laboratory allowed learners to wash the apparatus used during the experiment. After cleaning the apparatus and work benches, learners moved back to the front desk to complete their worksheets (Annexure P) which had been given to them by Mrs Hefer during the pre-practical lesson. The learners used the second period to complete the write up for the experiment.

Effectiveness of Practical Work in School B

Mrs Hefer's laboratory is well resourced. The laboratory also has a supply of electricity and water. There was enough equipment available to do the experiment. The availability of the equipment and a small class allowed Mrs Hefer to divide the learners into small groups. The small groups allowed every learner in the group to be involved in some aspect of the experiment. The involvement in experiment allowed learners to acquire skills such as measuring, observation and recording of data. Acquisition of manipulative skills was therefore better in School B. Mrs Hefer used a double period for the experiment. This provided the learners with ample time to conduct the experiment and to complete the write up for the experiment. The allocation of double periods on the school timetable for Physical Sciences provides adequate time for learners to conduct and complete experiments. CAPS require experiments and write ups of the experiments to be completed during school time and not as homework. It is therefore imperative that teachers make use of a double period when doing practical work in order to complete the experiment and write up during the practical lesson as required by CAPS.

4.3 Findings from the interview of the Educators

The analysis was conducted based on the transcript of the interviews (Annexure N) and findings in the observations as already reported in Section 4.2. The analyses have however been done according to themes as in the interview schedule (Annexure B).

4.3.1 Teacher Training

The responses of the participants recorded during the interview in respect of teacher training are presented in Table 4.1. The interview with the participating teachers indicated that the training for the implementation of CAPS was not adequate.

Table 4.1: Teacher Training

	School A – Mr Jere	School B – Mrs Hefer
Attended CAPS training	Yes	Yes –Facilitator
Did the training prepare you adequately?	No	More relevant material is needed

The shortcoming of the training by the Education Department Officials highlighted by the teachers was the inadequate hands on experience in practical work. As practical work forms an important part in the teaching of the Physical Sciences, it is imperative that teachers obtain experience in conducting these practical tasks. This aspect of the training was clearly lacking with most of the time being spent reading through the CAPS document. The participant teachers indicated that there needs to be more workshops that would give teachers the opportunity to do the prescribed and recommended experiments under the supervision of the subject advisors or subject specialists. The practice that teachers will obtain from these workshops will enhance the effectiveness of practical work in the Physical Sciences classroom.

4.3.2 Practical work

The response of the participants in respect of the impact of practical work on the teaching of science in Grade 10 is presented in Table 4.2.

Table 4.2: Practical work

	School A – Mr Jere	School B – Mrs Hefer
Practical work	Do not prepare learners for matric examinations	Understanding is improved by practical work

The interview with the teachers and the observation of the practical lesson did take place during the first school term. Both these teachers were preparing to conduct the prescribed experiment which was scheduled for the first term formal assessment task indicated on the Formal Programme of Assessment. Mr Jere, whose school was the less resourced in this study, stated that he "conducts practical work in order to satisfy the requirements of the Programme of Assessment". Mrs Hefer, who teaches in a well-resourced school, indicated that she involves practical work in the form of demonstrations or experiments in almost every lesson. This approach to teaching of the Physical Sciences is in keeping with the requirements of CAPS which requires teachers to link theoretical concepts to practical experiences.

Mr Jere also stated that he does not focus on practical work during his class teaching since practical work does not prepare the learners for the matric examination. He stated that the matric examination is content oriented and does not focus on practical work. Mrs Hefer on the other hand states that she uses practical work because it helps learners to better understand concepts that are taught. Mrs Hefer did indicate that she practices experiments or demonstrations before they are done in front of the class in order to be confident that the experiment or demonstrations works and to give learners a positive experience.

4.3.3 Resources

The responses of the participants in respect of the resources required to conduct practical work in their respective schools is presented in Table 4.3.

Table 4.3: Resources

	School A – Mr Jere	School B – Mrs Hefer
Well-resourced or poorly	Poorly resourced, chemicals expired, equipment damaged	Well resourced, assisted by a private company

Mr Jere indicated that he experienced challenges in doing practical work because of the lack of resources at the school. He did indicate that whenever possible he borrows equipment from neighbouring schools in order to conduct experiments mainly for assessment purposes. He also indicated that because his laboratory is under resourced, he does organise excursions to SciBono were learners are allowed to perform some of the experiments. He mentioned that the equipment that is in his laboratory is old or damaged and that the chemicals that are present are expired (Muwanga-Zake, 1998).

Mrs Hefer indicated that her school is supported by a private company. Her laboratory is well resourced and she is capable of conducting both the prescribed and recommended practical activities with her learners.

4.3.4 Time for conducting practical work

The responses of the participants in respect of the time required to teach the content of the Physical Sciences in Grade 10 including the time required for test, examination and preparing, conducting and assessing practical work is presented in Table 4.4.

Table 4.4: Time for conducting practical work

	School A – Mr Jere	School B – Mrs Hefer
Adequate time	Adequate time depends on how school spreads time e.g. double periods	Not enough for learners understanding, preparation of practical work, laboratory assistants required

The time allocated for the teaching of the Physical Sciences in Grade 10 is 160 hours per year. Mr Jere indicated that the time for completing the syllabus would be adequate. He also

mentioned that the time allocated should be included on the school timetable as double and single periods. Double periods could be used for practical work or assessment tasks e.g. test, assignments etc. During the observation of the practical lesson conducted by Mr Jere, it was noted that the practical lesson was conducted in a single period. The learners did not have sufficient time to complete the experiment. This indicated that Mr Jere did not carefully consider the time the learners would require in order to complete the experiment and to complete the write up for the experiment. In addition, Mr Jere used his non-teaching period to organise the material and equipment required for his practical lesson.

Mrs Hefer stated that the time allocated for Grade 10 physical Sciences was not enough for teaching and for conducting practical work. She indicated that learners needed more time to grasps concepts taught in Physical Sciences. She also stated the need for schools to be provided with laboratory assistants to prepare practical lessons and to set up apparatus for experiment and to store the apparatus after the experiment is completed. It was observed that Mrs Hefer just like Mr Jere utilised her non-teaching period to organise the material required for her practical lesson.

4.3.5 Departmental Assistance

The implementation of the new curriculum in schools requires the support and involvement of the various components of the Department of Basic Education. The provision of infrastructure, policy documents, professional development, etc. is required in order to implement the curriculum effectively. Table 4.5 presents the responses of the participants with regard to the effective implementation of practical work in the classroom.

Table 4.5: Departmental Assistance

	School A – Mr Jere	School B – Mrs Hefer
Department Assistance	Supply of basic equipment, subject advisor assistance, time	Time not enough, class sizes, stop red tap e.g. moderation, administration

Mr Jere and Mrs Hefer indicated that assistance from the Department of Education was required in order to implement CAPS effectively in schools. Mr Jere indicated that his school should be supplied with the basic equipment in order for CAPS to be implemented effectively. He added that subject advisors need to provide more assistance to teachers and to visit schools with the intention of helping teachers in the implementation of CAPS in the classroom. At the present moment, subject advisors are visiting schools for monitoring purposes only rather than providing classroom assistance to teachers. Cluster meetings held every term is for the purpose of passing information to educators rather than providing support.

Mrs Hefer noted that more time is needed to teach and conduct practical lessons as required by CAPS. The work load of teachers of the Physical Sciences warrants the introduction of laboratory assistant to assist in setting up practical work and to be laboratory managers. She also noted that teachers spend too much of time on administrative work at the expense of teaching science.

4.3.6 Class sizes

During the observation of the practical lesson, it was noted that the size of the Physical Sciences class in School A differed significantly from the class size in School B. Table 4.6 presents the number of learners in each school and how the size of the class impacts on the size of the groups that are formed when doing practical work.

Table 4.6: Class Sizes

	School A – Mr Jere	School B – Mrs Hefer
No of learners	47	27
Group work	Yes	Yes
Group size	12 per group	3-4 per group

Mr Jere's Physical Sciences class consisted of 47 learners. These learners were divided into into four groups of 12 learners each. It was observed that all the learners were not actively engaged in the experiment as there was a shortage of equipment. There were only four thermometers for the experiment. This shortage led to the formation of four groups which did not allow for all learners to be actively involved in taking readings as is required by this practical task.

Mrs Hefer's class on the other hand had only 27 learners. As this school is well resourced, the class was divided into smaller groups. The class was divided into groups of 3 to 4 learners. This allowed each member in the groups to be involved in the experiment thereby allowing learners to develop the skills envisaged by the studying of the Physical Sciences. Class size does hamper the implementation of effective practical work in schools.

4.4 Discussion of findings

The main challenges revealed in this study to use of practical work in teaching were lack of resources, class sizes and time provided to setup practical tasks during teaching. I discuss these here in turn.

4.4.1 Resources

Resources in the form of laboratories, equipment, basic services seem to impact on the use of practical work. Schools that are under resourced tended to do less practical work compared to schools that have adequate resources as evident from this study. In this study, school B that was better resourced and could do better organized practical work than school A that had fewer resources and poorer infrastructure. While Hattingh et.al. (2007) have argued that there is no correlation between resources and practical work, this study has reported otherwise, and argues instead that improving resources will make some difference when accompanied by other interventions as well. These interventions include the motivation of teachers, training of teachers (Ajaja, 2009) and training of how to use equipment supplied to schools (Muwanga-Zake, 1998). Teachers who are motivated to do practical work will find ways to do so even in the most poorly resourced schools (Hattingh, et.al 2007). In a study commissioned by the Department of Education (2000b), teachers find ways to address the shortage of apparatus by using videos, using demonstrations and improvisation. Since CAPS emphasises the use of practical work during teaching and as part of the learners' assessment, it is imperative that the Department of Education ensure that schools have the necessary resources in order to facilitate the effective implementation of CAPS in schools.

4.4.2 Class sizes

In this study, the class sizes were 47 in School A and 27 in School B; this led to different arrangements for practical work. In school B for example, the group sizes ranged between 3 - 4 learners per group, while in school A with a larger class size, each group had 12 learners. The size of classes doing Physical Sciences can also contribute to the effective implementation of CAPS. The class size in some schools is large. These large classes do have an impact on the use of practical work. Stoffels (2005) notes that a relatively large class made it cumbersome to facilitate group practical work. Teachers concern over learner discipline during group practical work was also of concern. In addition to problems related to classroom control, teachers noted that because of the large classes opportunities for learners to do experiments by themselves or in a group were severely limited. This meant that teachers had to resort to teacher demonstrations. Large class size does not allow for the effective implementation of CAPS which requires learners "to focus on practical aspects and the process skills required for scientific inquiring skills and problem solving" (DBE, 2011a: p. 144). The overcrowded classroom will hamper the attainment of such skills. This would be worse if in addition to the large classes, there was shortage of laboratory equipment in

schools; this will not allow for learners to conduct practical work individually. Teachers have to therefore resort to group work or classroom demonstrations as described in Section 4.4.1.

4.4.3 Time

The time allocated for Physical Sciences is 4 hours per week with 40 weeks in total for Grade 10. This time is allocated for assessment, teaching of the content, concepts and skills including the practical work (DBE, 2011a). Stoffels (2005, p. 158) found that the workload of teaches and the administrative work impacted negatively on the teachers capacity to plan and setup practical work. The time crunch stifled their ability to collaborate with colleagues on practical activities. Muwanga-Zake (1998) suggests that science teachers should be allocated fewer teaching periods so that teachers can manage the laboratories and prepare practical activities. Teachers involved in this study had to make use of their non-teaching periods to prepare for practical work. At this time teachers in public schools are overburdened in that they have to teach a curriculum, prepare practical tasks, manage a laboratory and equipment, order chemicals and replace equipment and complete administrative tasks such as class mark sheets, lesson preparations, class registers, moderation and setting and marking of test and examination.

At present the administrative load of teachers will have an impact on the successful implementation of CAPS. The time that is allocated to the teaching of Physical Sciences is shared with other administrative tasks which hamper the effective implementation of CAPS. This is the reason that teachers call for the laboratory assistants being made available to assist science teachers (Thair & Treagust, 1999, p. 367). Teachers felt that to engage students in more student-centred teaching practices in physics, more preparation time was necessary to prepare teaching materials for classroom and practical activities, and that the time in class required for these activities created difficulties in covering the content in an already overloaded curriculum. With such a massive teaching load there is obviously a serious reduction in the amount of time available for lesson preparation and thus teachers find it easier and more time effective to use the transmission approach rather than incorporate practical activities in their teaching. A challenge therefore still exists to the successful implementation of the practical requirement in the teaching of physical science.

Evidently, the findings of this research project do support the findings of other researchers on the use of practical work in sciences.

4.5 Chapter Summary

In this chapter I have presented and analysed the observation and the interview data. The findings have been discussed and compared to the findings in existing studies. In the next chapter, I focus on answering the research questions, the overall significance of the study, the recommendations for improving science education in schools, the implications for further study, the limitations of the study, the reflection on the study process and a conclusion.

CHAPTER 5: Conclusions and Way Forward

5.1 Introduction

In this chapter I give a summary of the findings of this research project. I also focus on the significance of the study and make recommendations based on the findings. The limitations of this study and the implications for future study are also considered. Also included are my reflections on the study and the lessons I learnt in its implementation.

The research questions this study addressed as already provided Sections 1.3 and 4.1 are reproduced here for convenience:

a) Do schools have the necessary resources to conduct practical work?

b) Have teachers been adequately trained to conduct practical work in their classrooms?

c) What other sources of support can be accessed by Physical Sciences teachers when doing practical work?

How the data were collected has been discussed in detail in Sections 3.5 and 3.6; the approach taken to analyse these data has been described in Section 4.1. I next present a summary of the findings.

5.2 Summary of findings

In this section I answer the research questions using the data obtained from the classroom observations and the interviews with teachers.

a) Do schools have the necessary resources to conduct practical work in their schools?

School A: The visit to Mr Jere's school revealed that the school was provided with the basic services such as water and electricity. During the classroom observation of the practical lesson, it was noted that the laboratory did not have a supply of electricity and water at the laboratory desks. Water and electricity are essential in order to conduct practical lessons effectively and to allow learners to conduct practical work individually or in groups. The lack of these services in the laboratory does hamper the implementation of CAPS for Physical Sciences in Grade 10.

The absence of water and electricity required that the teacher needed to make preparations before the practical lesson to have boiling water and ice organised for the practical lesson. This does impact on the time that teachers need in order to prepare to conduct practical work effectively.

Mr Jere used group work in order to conduct the experiment. The groups comprised 12 learners per group. The large groups were due to the shortage of equipment such as thermometers. Mr Jere indicated that he had to borrow thermometers from a neighbouring school. The four thermometers that were borrowed resulted in four groups of 12 learners per group. The groups were too large for any meaningful engagement of the learners in the practical work.

School B: A visit to Mrs Hefer's school indicated that the school is supplied with essential services such as electricity and water; these were adequately provided for at each desk in the Physical Science laboratory. This allows for learners to conduct practical work individually or in groups. My observation during the practical lesson does indicate that learners can engage in effective practical work if these essential services are available in the laboratory.

The availability of adequate equipment does allow learners to engage in effective practical work and hence allows learners to develop skills such as measuring, recording of data, writing reports and observation. The availability of apparatus and the use of small groups keep all learners engaged in the experiment.

b) How do teachers implement/use practical work during their lessons in the Physical sciences?

School A: CAPS require that teachers incorporate practical work in the teaching of the Physical Sciences in order to enhance understanding of concepts. Mr Jere stated that he conducts practical work once a term in order to fulfil the assessment requirements of CAPS. He indicated that he very seldom uses practical work during his Physical Sciences lessons because of the lack of equipment in the laboratory and the fact that there is no matric assessment of practical work.

During the observation of the practical lesson it was noted that the lack of equipment in the laboratory resulted in practical groups being very large. This prevented learners from acquiring the skills such as measuring and observing because not all learners handled and manipulated the equipment. Mr Jere also indicated that the lack of equipment also limited the use of demonstrations during Physical Sciences lessons.

School B: Mrs Hefer indicated that she uses practical work in almost all lessons. She stated that her laboratory is fully resourced thanks to a private company which sponsors the resources required for the teaching of Physical Sciences.

During the observation of Mrs Hefer's lesson, it was evident that there was no shortage of laboratory equipment. The small groups of 3-4 learners allowed all learners to engage in the

practical work. Each learner in the group was involved in some task during the experiment. The skill such as measuring and recording was being developed during the experiment.

Mrs Hefer also mentioned that because she has all the equipment at her disposal, she was able to incorporate practical demonstrations in almost all her lessons. She also stated that using practical demonstrations helps learners to understand concepts being taught.

c) Have teachers undergone adequate training to conduct practical work in their classrooms?

School A: Mr Jere did attend the CAPS training for grade 10 Physical Sciences educators organised by the Gauteng Department of Education. The training took place over 3 days during the October school holidays. Mr Jere stated that the training was not adequate and did not focus on practical work which is emphasised in the CAPS document. He stated that the training involved more reading through the CAPS document rather than providing hands on experience for teachers. Compared to his own teacher training, the CAPS training added no value.

School B: Mrs Hefer attended and facilitated the CAPS training for the Grade 10 Physical Sciences teachers. She indicated that that some of the practical activities prescribed for CAPS did not work in the classroom and suggested that CAPS should prescribe more relevant practical activities. She also indicated that teachers needed to do the practical work before they are conducted in the classroom in order to make sure that they really work. This would help to provide a positive learning experience for the learners.

d) Are there any other sources of support from the Department of Education or from within the schools for Physical Sciences teachers?

School A: Mr Jere did indicate that more support is needed from the Department of Education that would support the effective implementation of practical work in schools. He stated that his school did not have adequate resources to conduct effective practical work. He also stated that the class sizes and the lack of basic services did not allow for practical work to be conducted. He also stated that subject advisors did not provide adequate support and advice to assist in the implementation of practical work.

The time allocated to Physical Sciences on the school timetable needs to be adjusted so that only double periods are available to conduct practical work. During the observation of the practical lesson, it was noted that the single period used was not adequate to complete the practical task successfully. Pre-preparation for practical work took place prior to the practical lesson during the teacher's free period. This indicates that the time available for teachers to

setup practical tasks in the laboratory is not adequate. More time needs to be allocated to teachers in order to setup and store equipment used for the practical tasks. This also calls for the employment of laboratory assistants.

School B: Mrs Hefer indicated that the reduction in class sizes would contribute to the effective implementation of practical work in schools. While Mrs Hefer's laboratory is well equipped, the laboratory space is small to manage big classes. She also indicated that the time available to prepare and conduct practical work needs to be adjusted as the time is not adequate. She also mentioned that the amount of administration work required by the Department of Education was also a factor that was time consuming and did not allow ample time for teachers to prepare and conduct practical work.

During the interview with Mrs Hefer, I noted that she was busy preparing for her practical lesson during her free period before the practical lesson. This is an indication that teachers require more time to prepare and conduct practical work in their classes. It was also stated that the equipment needs to be stored away before the next class arrives at the laboratory. This is the reason Mrs Hefer suggested that Physical Science laboratories require a laboratory assistant in order to setup equipment and to store the equipment after practical lessons are conducted.

5.3 Recommendations

5.3.1 School Laboratories

The Department of Basic Education should make provision for chemicals and apparatus to all schools in order for teachers to be able to conduct both formal and informal assessment tasks with their learners. Science equipment supplied to schools should be accompanied by training on how to use the equipment. It is important that learners should learn Physical Sciences through an enquiry approach to increase interest and motivation. The Department of Basic Education should provide the necessary infrastructure and enabling environment to make science education thrive.

The Department of Education must ensure that all school have the basic needs for teaching and learning to take place. Basic needs would include qualified teachers, well-furnished classrooms, electricity, water, libraries and electronic equipment. Education in schools will improve if these necessities are provided in all schools so that all schools can implement the new curriculum successfully. A thorough inventory of schools must be undertaken to determine the shortfall and this should be rectified.

5.3.2 In-service Training

In-service training and workshops needs to be conducted to assist teachers in implementing practical work in their classes. It is of vital importance that education officials conduct school based, cluster, provincial and national workshops in Physical Sciences rather than the sketchy kind conducted to prepare teachers like was the case reported in this study. Continual professional development is imperative for all educators to keep up to date with the latest changes in education. In-service training should target teachers' content, methods including laboratory training and assessment strategies. Most teachers that are presently in schools have been there for many years. A minority of teachers enter the profession with knowledge of the new curriculum. It the imperative for teachers at schools to receive in-service training so that they can be brought on board in the implementation of the new curriculum.

In-service training can take the form of short workshops, vacation classes or well-planned circulars. In-service training needs to be consistent, motivating and progressive so that teachers will be eager to participate in these programmes. The in-service training needs to be relevant and current to be of use to teachers. As documented in Oyoo (2013, p. 474), Calloids, Gottelmann-Duret and Lewin (1997) have outlined the following approaches to in-service training that can be adopted in future by the Department of Education to train or in-service teachers:

- In-service days where teachers are gathered locally at special centers to discuss particular topics
- Short in-service courses lasting up to a week, usually residential in regional centers run by national staff members
- Longer in-service courses lasting three months or more usually associated with certification and upgrading
- School based in-service support during and after school hours, located in schools.

In addition to or in place of in-service training, subject advisors should visit schools in order to assist teachers in conducting practical work. Subject advisors should assist teachers at classroom level.

5.3.3 Teacher Training

Tertiary institutions must offer programmes in the implementation of the current curriculum namely CAPS. Teacher training institutions should place greater emphasis on using practical work in their teaching which would be in keeping with the requirements of CAPS. Science teachers must pass practical courses and laboratory management should be part of their

qualification as teachers. Science teachers must be trained in the science subjects that form part of the school science curriculum. Training should include the various methods for teaching, relevant practical work for each topic of the curriculum, effective group work activities which could be used to explain and engage learners in the content, using effective assessment techniques to determine learners understanding of the content as well to diagnose misconceptions learners may hold. Besides academic knowledge about the science curriculum, teachers must receive training in pedagogical matters such as subject matter transformation for teaching to take place.

Pre-service training with sufficient and monitored classroom teaching experience is necessary to expose the new teachers to the classroom/teaching environment. Pre-service training will give future teachers the opportunity to test their content knowledge as well as to choose appropriate teaching methods. This study shares with Ogunniyi (1996), the view that it would be better to prepare students for teaching using more realistic and relevant science courses closely matched to the school science curriculum.

Teachers must also receive training in the use of group work in the classroom. Many teachers are not aware of how to use group work in the classroom and how to prepare activities that are suitable for group work. As the new curriculum emphasises group work to encourage learners to work together, teacher as well learner development in group dynamics would be essential. To ensure the success of this, curriculum developers and teacher trainers need to work closely with teacher trainers so that the training process will encompass all aspects in the teacher training programme that are envisaged by the curriculum. The shortage of practical resources in most schools requires teachers to use group work in the classrooms and laboratories, therefore the teacher training must cover the use of group work by teachers.

5.3.4 Consultation with teachers and teachers unions.

Prior consultation with the teachers and teacher unions is essential as teachers are the implementers of the new curriculum. A bottom up approach, rather than a top down approach will lead to greater success in implementation of the curriculum. Teachers have the experience of the classroom, the contexts and the learners and will be aware of what needs to be considered when implementing a new curriculum.

5.3.5 Improvisation

With the shortage of laboratory equipment and even laboratories in most schools in South Africa, teachers need to make use of locally available resources that can help in teaching the

concepts in Physical Science. By relating science concepts to the 'students immediate environment' (Oyoo, 2013, p. 468) would help learners in understanding the concepts and make science more relevant. Teachers should consider using everyday items for experiments and demonstration. This is the essence of being innovative in science teaching (Oyoo, 2013). Improvisation needs to be considered to include the use of our environment to enhance teaching (Carelse, 1983). Swift (1983) suggests that the teacher should be aware of all potential visual aids in the vicinity.

5.4 The messages from this study

The change in government in South Africa since 1994 has brought about a series of changes to the National Education Curriculum. The change in the curriculum from the Nated 550 to the current CAPS has brought about changes in teaching approaches, curricula and assessment guidelines.

Although these changes have been an improvement of the previous curricula, the implementation of the current CAPS curriculum is still problematic. This study has highlighted a specific area of Physical Sciences in Grade 10 in respect to the use of practical work as a teaching tool and as an assessment instrument.

This study has revealed that schools in the sample are encountering problems with regard to the implementation of practical work. The factors that contribute to the poor implementation of practical work in the Physical Sciences classroom include lack of laboratory equipment, the inadequate amount time that is required to prepare and conduct practical work and the large class sizes.

Although the curriculum change is meant to improve the performance of learners in science, the need for the provision of basic resources, both physical and human resources cannot be over emphasised. The Department of Education will need to direct more financial and human resources towards improving the conditions at schools so that CAPS can be implemented effectively. This will in turn help to produce learners who will be able to enrol at higher education institutions in the fields of medicine, engineering, technology and science. These graduates will then be able to contribute to the economy locally and globally.

A comment for a better designed study has been made in section 5.4. However, the significance of the current study still stands out when the findings in this study are seen as a reflection of the reality in the context of the participant schools and as may suggest the situation in similar school contexts. This is in the following ways: 1) the result of the current

study provides the curriculum designers with an overview of what to do in helping teachers to do practical work meaningfully; 2) the findings provide the school Principals and their School Management Teams (SMT) with a greater insight into the challenges that Physical Sciences teachers encounter when implementing CAPS in their schools; 3) after a consideration of these findings, the subject advisors will be able to improve on the short comings of the CAPS training attended by the teachers; 4) the findings will alert the District Officials to be more aware of the lack of resources in schools for them to be more proactive in facilitating the provisions of resources to under resourced schools. Above all, the findings in this study will provide feedback to policy makers on the implementation of CAPS.

5.5 My Reflections: Implications for further study

As limitations of this study, it is acknowledged that it did not look into exactly what happens in the cluster meetings as well as the extent of the impact of those meetings in assisting the teachers to engage with practical work. Also only two school and two teachers were involved in this research project. The results of this study can therefore not be generalised. 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 large sample in order to obtain a clearer idea of the factors that influence the use of practical work in the Physical Sciences classrooms. Such a study should address the issue of impact of the lack of resources on the assessment of physical sciences learners and teachers' practice during practical work.

Looking back at the design of approach to data collection that I must have insisted on and my implementation of the data collection process, I, during the write up of this research report, realised that I would have benefitted from video records of each of the lessons to remind me of what transpired in each practical lessons I observed in this study. I therefore can suggest that as a means to aid better data collection in future studies, video records of each lesson be obtained for review of the recordings while completing the write-up. With this realization, I am now prepared to plan and implement a better research study.

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ANNEXURES

Annexure A - Observation Schedule

Time: _____
Place: _____
Setting: _____
Role of observer: _____

INFRA-STRUCTURE

			Comment
1. Laboratory	Yes	No	_____
2. Electricity	Yes	No	_____
3. Water	Yes	No	_____
4. Laboratory equipment	Yes	No	_____

CLASSROOM OBSERVATION

	5 min					10 min					15 min					20 min					25 min					30 min					35 min					40 min				
The teacher explains to the learners what needs to be done in the practical task.																																							
The teacher answers the learner's questions.																																							
The teacher discusses the results of the practical activity.																																							
Learners gather apparatus to do practical work.																																							
Learners are																																							

| | | |

Annexure B - Interview Schedule

1. For how many years have you been teaching Physical Sciences?

2. What is your highest qualification in the subject?

3. Did you attend the CAPS training for Grade 10 Physical Sciences?

4. Did the training prepare you adequately for implementing CAPS in the Grade 10 Physical Sciences class?

5. What does the assessment guidelines say about the purpose of practical work?

6. CAPs mentions prescribed and recommended practical activities. How are these activities different from each other?

7. Have you done any of the prescribed activities thus far?

8. What challenges did you encounter when doing the prescribed activities?

9. How did you overcome these challenges?

10. Have you done any of the recommended activities?

11. What challenges did you encounter when doing the recommended activities?

12. How did you overcome these challenges?

13. Do you regard your school as a well resourced or poorly resourced school in terms of science equipment? Elaborate.

14. The results in Physical Sciences over the years have been reported to be poor. How do you think the use or lack of use of practical work in teaching contributed to these poor results.

15. CAPS prescribe 160 hours (40 hours per term) for Grade 10 Physical Sciences. Do you think that this is sufficient time for teaching the content; preparing, conducting and assessing practical work and conducting tests and examinations? Elaborate.

16. If you were asked by education officials to suggest ways in which science practical work can be conducted effectively in your schools, what suggestions would you put forward?

Annexure C - Participant Information Sheet

My name is Aroon Kumar Singh. I am a teacher at Vryburger High School in Primrose, Germiston. I am a student at Witwatersrand University. As part of the fulfilment of the Master of Science degree, I am expected to produce a research report.

My research study focuses on the factors that influence the use of practical work in the Grade 10 Physical Sciences classroom. The investigation intends to determine the factors that promote the use of practical work as well as the factors that hinder the use of practical work in the teaching of Physical Sciences.

The findings of the research will highlight the challenges that teachers encounter in the Physical Sciences classrooms. The findings will assist education officials to put measures in place to overcome the challenges encountered by teachers so that the teaching and learning of Physical Sciences in schools will improve.

This research project requires voluntary participation of teachers and learners in the Grade 10 Physical Sciences classroom. The research methods that will be used are observations and interviews. A Physical Sciences lesson will be observed. Field notes will be recorded of the interaction of the teacher and learners during the lesson. After the lesson the teacher will be interviewed using an interview schedule. Both the learners and the teacher are free to withdraw from the research project at any time should they desire to do so. Teachers and learners will be invited formally to participate in the research by means of a letter and consent form.

The data gathered will only be used for this research and will be destroyed as soon as the research report is completed. Confidentiality and anonymity of the participants will be guaranteed by the use of a coding system. The research report will be made available to the participants and the Gauteng Department of Education.

Please do not hesitate to contact me for any comments or questions about the research project. My contact details are as follows:

Cell No: 0845835895

Work: 011 8289047

Email: singh47ak@gmail.com

Yours faithfully

_____

A.K.Singh

Annexure D - Letter to the Principal

To the Principal: _____

My name is Aroon Kumar Singh. I am a student at University of the Witwatersrand. I would like to request permission to observe and collect data from your Grade 10 Physical Sciences classroom. In addition I would like to interview the Physical Sciences Grade 10 teacher. I am interested in the factors that influence the use of practical work in Physical Sciences in Grade 10. The Curriculum and Assessment Policy Statement (CAPS) places great emphasis on the use of practical work in the teaching of the Physical Sciences. My investigation intends to determine the challenges encountered by teachers and the schools in implementing CAPS.

I will not interrupt the normal running of the school. The data collected will be confidential and only used for the research project. The names of the teachers and the school would be confidential. The data collected will be destroyed once the research project is complete.

The teacher who will be part of the study will benefit from the enlightenment that will arise from the data. The findings of the research will also provide insight to education officials regarding the implementation process of CAPS in Grade 10 Physical Sciences.

I am looking forward to your response as soon as possible. Do not hesitate to contact me for any comment or question arising from this request. My contact details are as follows:

Cell No. : 084 5838595

Email: singh47ak@gmail.com

Thank You

_____

A.K. Singh

Annexure E - Principals Consent Form

The following ethical considerations are outlined to inform your consent thereof:

- You are under no obligation to participate in the study. If you feel that you do not want to be part of the study, you a free to withdraw at any time without any sanctions being imposed.
- The information obtained from the study will be kept confidential and anonymous at all times.
- The information the researcher obtains from your school will in no way be used to inform others (example other schools, department officials, politicians or parents) about your school in particular.
- You have the right to ask questions about this study. The researcher can be contacted at 084 583 8595.

In choosing to participate in this study, you agree that:

- I understand the nature of this study.
- I understand that I may withdraw from the study without supplying reasons.
- I was provided with the opportunity and time to think about allowing my school to participate in the study.
- I was not pressurised in any way to allow my school to participate.
- I understand that participation in this study is completely voluntary.
- I understand that this research study has been approved by the relevant committees at the University of the Witwatersrand and the Gauteng Department of Education.

I _____ the Principal of _____ school hereby give consent to Aroon Kumar Singh to involve the Grade 10 Physical Sciences teachers and learners in his research.

_____ _____

Signature of Principal Date

Annexure F - Letter to the Teacher

Dear Colleague

My name is Aroon kumar Singh. I am a teacher at Vryburger High School in Primrose, Germiston. I am a student at the University of the Witwatersrand. As part of the fulfilment of the Master of Science degree I am expected to produce a research report. I will be investigating the factors that influence the use of practical work in the Grade 10 Physical Sciences classroom within the context of the Curriculum and Assessment Policy Statements (CAPS). I would like you to be part of the study. Your participation in this study will be totally voluntary. I will collect data by means of classroom observation and teacher interviews. The data obtained will only be used for the fulfilment of the degree requirements. Confidentiality and anonymity will be guaranteed by the use of a coding system. The data obtained will be destroyed after the research is complete. You have the right to opt out of the research at any time during the study. The findings of research will be made available to you at end of the study. Your participation in this project will provide greater insight in to the implementation of CAPS. The findings of the research will inform education officials of the successes and challenges encountered by teachers.

I am looking forward to your response as soon as possible. Do not hesitate to contact me if you should have any comment or question arising for my request. You can contact me at:

Cell No: 084 5838595

Email: singh47ak@gmail.com

Thank You

_____

A.K.Singh

Annexure G - Teacher Consent Form

The following ethical considerations are outlined to inform your consent thereof:

- You are under no obligation to participate in the study. If you feel that you do not want to be part of the study, you a free to withdraw at any time without any sanctions being imposed.
- The information obtained from the study will be kept confidential and anonymous at all times.
- You will not be referred to individually.
- You have the right to ask questions about this study. The researcher can be contacted at 084 583 8595.

In choosing to participate in this study, you agree that:

- I understand the nature of this study.
- I understand that I may withdraw from the study without supplying reasons.
- I was provided with the opportunity and time to think about participating in the study.
- I was not pressurised in any way to participate in the study.
- I understand that participation in this study is completely voluntary.
- I understand that this research study has been approved by the relevant committees at the University of the Witwatersrand and the Gauteng Department of Education.

I _____ the teacher at

_____ school hereby give consent to Aroon Kumar Singh to be part of his research project.

_____ _____

Signature of teacher Date

Annexure H - Letter to the Parent

Dear Parent

My name is Aroon Kumar Singh. I am a teacher at Vryburger High School in Primrose, Germiston. I am a student at the Witwatersrand University. As part of the fulfilment of the Master of Science degree I am expected to produce a research report. I will be investigating the factors that influence the use of practical work in the Grade 10 Physical Sciences classroom within the context of the Curriculum and Assessment Policy Statements (CAPS). I would like to request your permission for your child who is in the Grade 10 Physical Sciences classroom to be part of the research project. Your child will only be observed during the lesson. Your child will in no way be harmed during the research project. The participation of your child in this research project will be totally voluntary.

I will collect data by means of classroom observation and teacher interviews. The data obtained will only be used for the fulfilment of the degree requirements. Confidentiality and anonymity will be guaranteed by using a coding system. The data obtained will be destroyed after the research is complete. Your child has the right withdraw from the study at any time. The findings of research will be made available to you at end of the project. Your child's participation in this project will provide greater insight in to the implementation of CAPS. The findings of the research will inform education officials of the successes and challenges encountered by teachers. The findings will also help to improve the teaching of Physical Sciences in Grade 10.

I am looking forward to your response as soon as possible. Do not hesitate to contact me if you should have any comment or question arising for my request. You can contact me at:

Cell No: 084 5838595

Email: singh47ak@gmail.com

Thank You

_____

A.K.Singh

Annexure I - Parent Consent Form

The following ethical considerations are outlined to inform your consent thereof:

- You are under no obligation to participate in the study. If you feel that you do not want your child to be part of the study, you are free to withdraw him/her at any time without any sanctions being imposed.
- The information obtained from the study will be kept confidential and anonymous at all times.
- Your child will not be referred to individually.
- You have the right to ask questions about this study. The researcher can be contacted at 084 583 8595.

In choosing to participate in this study, you agree that:

- I understand the nature of this study.
- I understand that I may withdraw my child from the study without supplying reasons.
- I was provided with the opportunity and time to think about allowing my child to participate in the study.
- I was not pressurised in any way to allow my child to participate.
- I understand that participation in this study is completely voluntary.
- I understand that this research study has been approved by the relevant committees at the University of the Witwatersrand and the Gauteng Department of Education.

I _____ the parent/guardian of _____ child/ward in grade 10 at _____ school hereby give consent to Aroon Kumar Singh to be part of his research project.

_____ _____

Signature of Parent Date

Annexure J - Letter to the Learner

Dear Learner

My name is Aroon Kumar Singh. I am a teacher at Vryburger High School in Primrose, Germiston. I am a student at the Witwatersrand University. As part of the fulfilment of the Master of Science degree I am expected to produce a research report. I will be investigating the factors that influence the use of practical work in the Grade 10 Physical Sciences classroom within the context of the Curriculum and Assessment Policy Statements (CAPS). I would like to invite you to participate in this research project. You will only be observed during the lesson. You will in no way be harmed during the research project. Your participation in this research project will be totally voluntary.

I will collect data by means of classroom observation. The data obtained will only be used for the fulfilment of the degree requirements. Confidentiality and anonymity will be guaranteed by using a coding system. The data obtained will be destroyed after the research is complete. You have the right withdraw from the study at any time. The findings of research will be made available to you at end of the project. Your participation in this project will provide greater insight in to the implementation of CAPS. The findings of the research will inform education officials of the successes and challenges encountered by teachers. The findings will also help to improve the teaching of Physical Sciences in Grade 10.

I am looking forward to your response as soon as possible. Do not hesitate to contact me if you should have any comment or question arising for my request. You can contact me at:

Cell No: 084 5838595

Email: singh47ak@gmail.com

Thank You

_____

A.K.Singh

Annexure K - Learner Consent Form

The following ethical considerations are outlined to inform your consent thereof:

- You are under no obligation to participate in the study. If you feel that you do not want to be part of the study, you are free to withdraw at any time without any sanctions being imposed.
- The information obtained from the study will be kept confidential and anonymous at all times.
- You will not be referred to individually.
- You have the right to ask questions about this study. The researcher can be contacted at 084 583 8595.

In choosing to participate in this study, you agree that:

- I understand the nature of this study.
- I understand that I may withdraw from the study without supplying reasons.
- I was provided with the opportunity and time to think about participating in the study.
- I was not pressurised in any way to participate.
- I understand that participation in this study is completely voluntary.
- I understand that this research study has been approved by the relevant committees at the University of the Witwatersrand and the Gauteng Department of Education.

I _____ a learner at in grade 10 at _____ school hereby give consent/do not give consent to Aroon Kumar Singh to be part of his research project.

_____ _____

Signature of learner Date

Annexure L – GDE Research Approval Letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. D2013/216

GDE RESEARCH APPROVAL LETTER

Date:	**8 October 2012**
Validity of Research Approval:	**4 February 2013 to 27 September 2013**
Name of Researcher:	**Singh A.K.**
Address of Researcher:	**54 Roos Street**
	Primrose
	Germiston
	1401
Telephone Number:	**011 822 3395 / 084 583 8595**
Fax Number:	**011 822 3395**
Email address:	**singh47ak@gmail.com**
Research Topic:	**Factors that influence the use of practical work in Grade 10 Physical Science classrooms**
Number and type of schools:	**TWO Secondary Schools**
District/s/HO	**Ekhuruleni North**

Re: Approval in Respect of Request to Conduct Research

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

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

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

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

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

Kind regards

.....

Dr David Makhado

Director: Knowledge Management and Research

DATE: 2012/10/08

Making education a societal priority

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

Annexure M – Ethics Clearance Letter

Wits School of Education

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

Student Number:
581396

Protocol Number:
2012ECE186

Date: 05-Mar-2013

Dear Aroon Kumar Singh

Application for Ethics Clearance: Master of Science

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

Factors that influence the use of practical work in the Grade 10 Physical Sciences classrooms.

The committee recently met and I am pleased to inform you that clearance was granted.

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

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

All the best with your research project.

Yours sincerely

M Mabeta

Matsie Mabeta
Wits School of Education
011 717 3416

Cc Supervisor: Dr. S Oyoo

Annexure N - ANALYSIS OF THE INTERVIEW SCHEDULE

	School A – Me Jere	**School B – Mrs Hefer**
1. Experience	8 yrs	22 yrs
2. Qualifications	MSc	Physic 11
3. Attended CAPS	Yes	Yes-facilitator
4. Did the training prepare you adequately?	No	More relevant material needed
5. Assessment guidelines		
6. Prescribed	Limits teacher innovation	Used for promotion
Recommended	Below expected level	
7. Done prescribed	One	One
8. Challenges	No equipment	Dept. activity did not work
9. Overcome challenges	Borrow equipment	Adapt/trying out/practising
	School not flexible, time factor	
10. Done recommended	Yes	Done most of them
11. Challenges	Equipment	No challenges
12. Overcome challenges	Borrow	No challenges
13. Well resourced or poorly	Poorly resourced, chemicals expired, damaged	Well resourced – Set point
14. Practical work?	Do not prepare learners for matric examinations	Understanding is improved by practical work
15. Adequate time (160 hrs per year)	Adequate, depends how school spreads time e.g. double periods	Time not enough for understanding, preparation, and lab. Assistants
16. Department assistance	Basic equipment, subject advisors, time,hands on activities, lab used as classes	Time not enough, class sizes, stop red tape e.g. administration, moderation
17. Frequency of practical work	1 per term	Regularly
18. Attitude of learners	Boys- practical activities	Better learners take Physical Sciences
19. Use of practical work daily to strengthen concepts	No – exam oriented	Yes

Annexure O - ANALYSIS OF OBSERVATION SCHEDULE

Category	School A	School B
1. Laboratory	Yes	Yes
2. Electricity	Not available at work bench	Yes
3. Water	Not available in the Laboratory	Yes
4.Laboratory equipment	Limited	Yes
5. No of learners	47	27
6. Group work	Yes	Yes
7. Group Size	12 per group	3-4 per group
8.Educator activity	Guide, answer questions, monitor work of learners,	Guides, answer questions, monitors learners
9. Skill developed	Recording, interpreting, measuring, observation	Recording, monitoring, observation, writing reports, interpreting
10. Time available	30 minute – single period	70 minutes – double period
11. worksheets	None	Yes
12. Teacher explains the practical task.	Done in pre-practical	Done in pre-practical
13. Teacher answers learner's questions.	Assists learners during practical	Teacher assists learners during practical
14. Teachers discuss results.	Practical not completed	Teachers guides learners in completing the worksheet
15. Learners gather apparatus	Learners collect apparatus	Apparatus displayed on work bench
16. Learners doing practical.	Yes	Yes
17. Learners clear apparatus.	Learners busy with practical – not completed	Yes
18. Learners discuss in groups.	No	Yes during the write-up
19. Learners view video.	No	No
20. Learners observe demonstration.	No	No

ANNEXURE P – Practical Worksheet

GRADE 10 **PHYSICAL SCIENCES** **FEBRUARY 2013**

EXPERIMENT: HEATING AND COOLING CURVE OF WATER

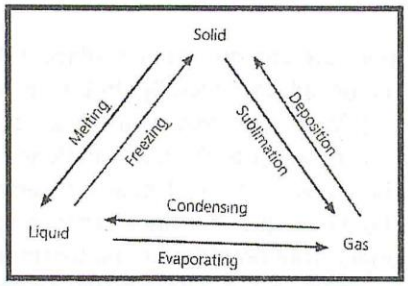
NAME: _____ **TOTAL: 30**

DATE GIVEN: _____

DUE DATE: _____

BACKGROUND INFORMATION:

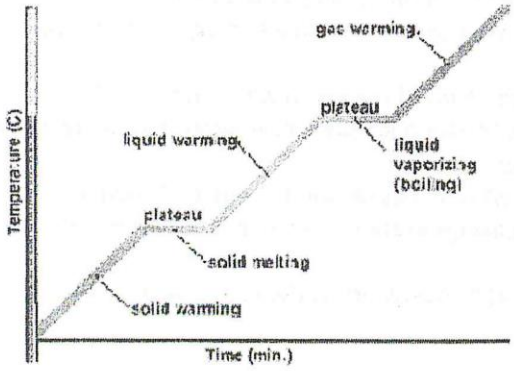
Physical change does not change the make-up of a substance at atomic and molecular level, but only the **arrangement of the particles changes.** Physical changes include melting, dissolving, boiling, evaporation, freezing, condensation and sublimation.



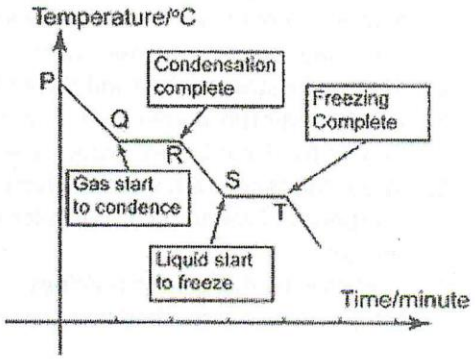
During physical change the forces between the particles change and these changes are **reversible,** e.g. water liquid can freeze to form ice, and ice can melt to form water liquid.

We can use either a heating or a cooling curve to indicate the changes in temperature of a substance during a time period.

HEATING CURVE: substance is heated



COOLING CURVE: substance is cooled



INSTRUCTIONS:

You will work in groups of 3 or 4. **Instructions for both heating and cooling of water have been given.** Your teacher will tell you whether your group will do a heating or a cooling curve.

You will need the following apparatus:

- a stopwatch
- graph paper
- a thermometer
- crushed ice
- hot water
- table salt (sodium chloride)**(cooling curve only)**
- A spatula for mixing ice and salt **(cooling curve only)**
- A small beaker
- A test tube

Method for heating curve:

1. Draw up a table with three columns using the headings: time in minutes, temperature in °C and observations.
2. Measure the room temperature and note your reading in the table.
3. ⅓ fill your test tube with crushed ice. Carefully stir the ice with the thermometer and find the temperature of the ice. Note your reading in the table.
4. Fill your small beaker with tap water to the 50ml mark and place your test tube with the ice in the water. Keep the thermometer in the ice, do not remove it at any time, not even to take readings. You may hold onto the thermometer to take readings, but not for too long.
5. Record at least three temperature readings on the thermometer and time on your stopwatch while the ice is melting and record on your table.
6. Gradually add hot water to the water in your beaker and take a temperature reading of the water in the test tube every minute until the water has reached room temperature.

Method for cooling curve:

1. Draw up a table with three columns using the headings: time in minutes, temperature in °C and observations.
2. ⅓ fill your test tube with warm water. Carefully stir the warm water with the thermometer and find the temperature of the hot water. Record your reading in the table.
3. ½ fill your beaker with crushed ice and place your test tube with warm water in the crushed ice so that the warm water can start to cool.
4. Record the starting time and the initial temperature of the warm water in the table.
5. Carefully stir the warm water with the thermometer and take a temperature reading every minute for five minutes. Record your readings.
6. When the temperature of the water in the test tube has reached about 10°C, add 4 teaspoons of salt to the crushed ice in the beaker and stir into the ice. Keep your test tube upright.
7. Take at least three more readings of the water temperature in the test tube after the temperature has reached freezing point.

RECORDING YOUR RESULTS:

1. TABLE: draw up a table as indicated in the instructions and record all readings.
2. GRAPH: plot the graph of temperature against time on the graph paper provided. Indicate clearly the melting/boiling point on your graph.

Rubric for table:

		YES	NO
1	Have all results been captured in the relevant column?		
2	Have observations been recorded in the table?		

(2)

Rubric for graph:

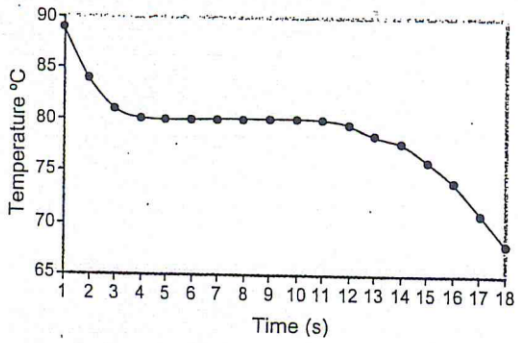
		0	1	2
1.	Graph title			
2.	X-axis title			
3.	Y-axis title			
4.	Scale on X-axis			
5.	Scale on Y-axis			
6.	Accuracy of data points			
7.	Shape of graph			
8.	Neatness of graph			
9.	Melting/boiling point indicated			

(13)

ANSWER THE FOLLOWING QUESTIONS:

QUESTION 1:

Below is the cooling curve from liquid to solid for a substance called naphthalene. Answer the questions that follow.



1.1 What is the melting point of naphthalene? (2)
1.2 Explain how you know this from the graph. (2)
1.3 Use the kinetic molecular theory to explain why the graph is 'flat' from time 4-11s. (4)
1.4 Find out the common name for naphthalene. (2)

QUESTION 2:

2.1 Use the table below and determine in which state each of the elements (A-D) will be at room temperature (25°C).

Element	Melting point (°C)	Boiling point (°C)
A	-218	-183
B	0	100
C	51	320
D	-20	40

(4)

2.2 Which substance (A,B,C or D) is water? (1)

GRADE 10 PHYSICAL SCIENCES DATE: _____

EXPERIMENT: HEATING AND COOLING CURVE OF WATER

ANSWER SHEET

NAME: _____

TABLE	GRAPH	Q1	Q2	TOTAL
(2)	(13)	(10)	(5)	30

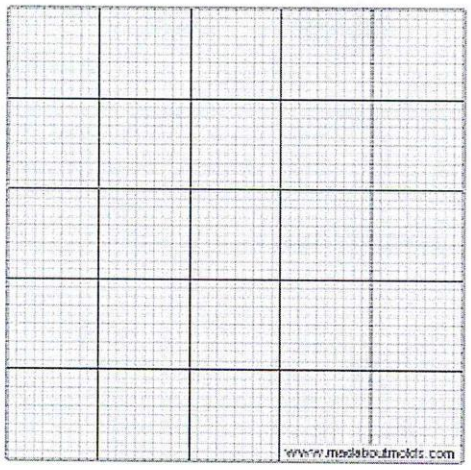
TABLE:

		YES	NO
1	Have all results been captured in the relevant column?		
2	Have observations been recorded in the table?		

GRAPH:



		0	1	2
1.	Graph title			
2.	X-axis title			
3.	Y-axis title			
4.	Scale on X-axis			
5.	Scale on Y-axis			
6.	Accuracy of data points			
7.	Shape of graph			
8.	Neatness of graph			
9.	Melting/boiling point indicated			



QUESTION 1:

QUESTION 2:

ANNEXURE Q – CAPS Training Circular

education
Department: Education
GAUTENG PROVINCE

Enquiries: Ernie Fynn
Tel Number: (011) 355 -0805

To : District Directors

Cc : Principals of Public and Independent Schools (For Action)
: Foundation Phase and Grade R Educators (For Action)
: Grade 10 Educators (For Action)
: District CAPS PMT's (For Action)

From : Ms Jeanette Moema
Acting Director – HRD

Date : 14 July 2011

Subject: Curriculum and Assessment Policy Statement (CAPS) Training

This memorandum serves to invite all Foundation Phase and Grade 10 educators as well as Grade R Practitioners from the registered sites to a compulsory Curriculum and Assessment Policy Statement (CAPS) training which is to be delivered during the week of 3 – 7 October 2011. Each district will host its own educators at selected training venues which will be communicated to you in due course by the respective District CAPS Project Management Teams.

Principals must ensure that all the relevant educators attend this training so that they acquire the necessary knowledge and skills which will enable them to implement this policy statement in the said grades in 2012. The training will be run from 8h00 in the morning until 15h00 in the afternoon at all the venues. Catering will be provided. The training is scheduled as follows:

PHASE	DURATION	DATES
Grade R	4 days	3 – 6 October ~~2012~~ 2011
Foundation Phase (Grade 1-3)	4 days	3 – 6 October ~~2012~~ 2011
FET Phase (Grade 10)	3 days	4 – 6 October ~~2012~~ 2011

Your cooperation in this regard will be highly appreciated.

Kind Regards

Ms Jeanette Moema
Acting Director: HRD

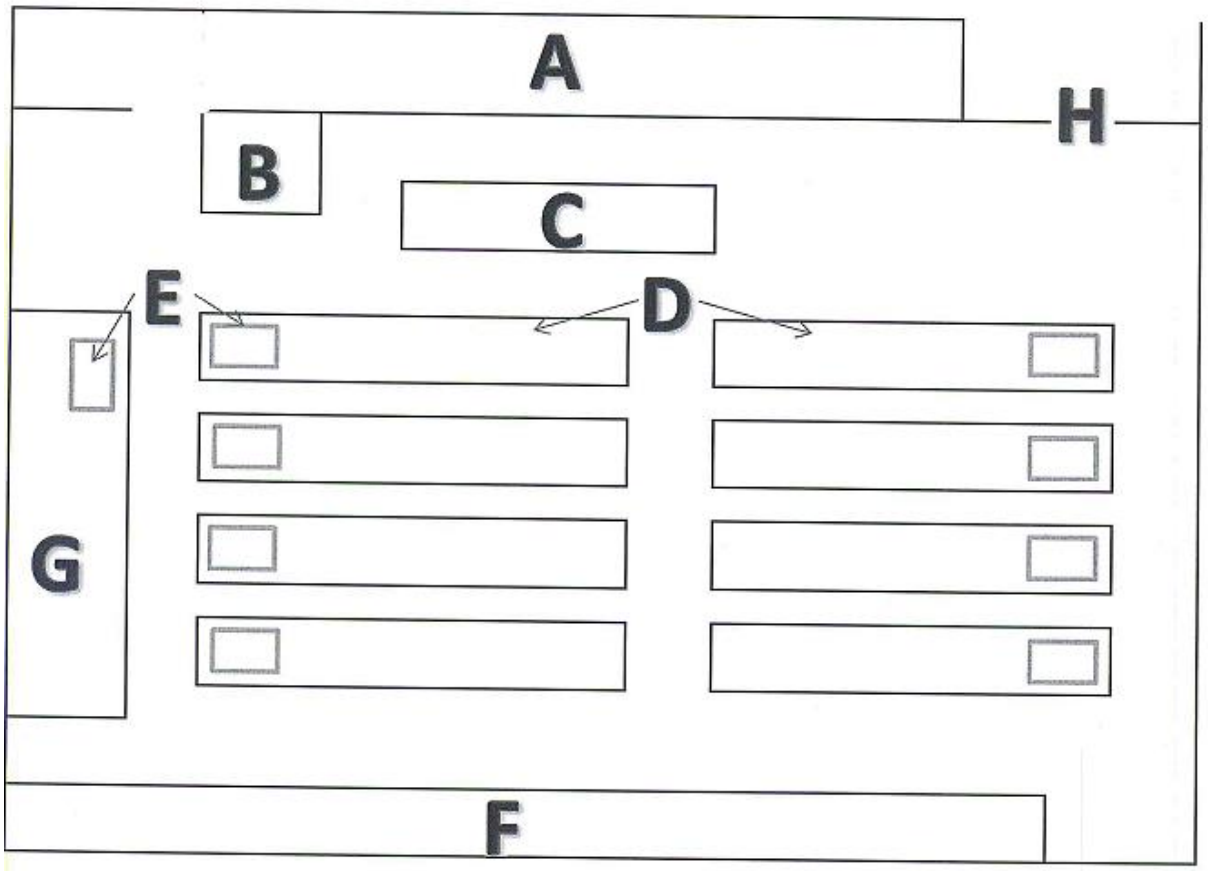
Mr M. Nkonyane/ Ms Z. Mthembu/ Ms A. Mali
Chief Director: Districts

Making education a societal priority

Office of the Director: Human Resource Development
7th Floor, 111 Commissioner Street, Johannesburg 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0401
Email: Zanel.Ngwenya@gauteng.gov.za
Website: www.education.gpg.gov.za

ANNEXURE R – Layout of Laboratory – School A

School A



A	Store Room	E	Sink
B	Fume Cupboard	F	Work Bench
C	Teachers Desk	G	Storage Cupboard
D	Laboratory Desk	H	Entrance

ANNEXURE S – Layout of Laboratory – School B

