UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF PRACTICAL WORK ON SHS STUDENTS' UNDERSTANDING OF SOME SELECTED TOPICS IN PHYSICS

DANIEL OLOGO

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DANIEL OLOGO

A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF PHILOSOPHY IN (SCIENCE) DEGREE

JULY, 2016

DECLARATION

Candidate's Declaration

I, **Daniel Ologo** hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

…………………………… ……………………

OLOGO DANIEL **DATE**

Supervisor's Declaration

This dissertation has been read and approved as meeting the requirements of the School of Research and Graduate Studies, University of Education, Winneba.

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Dr. K. D. TAALE **DATE**

(Supervisor)

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DEDICATION

I dedicate this dissertation to the Almighty God and all those I hold dear to my heart, especially my parents: Mr. Philip Quao and Mrs. Grace Quao; and my wife Dorothy Adu.

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ABSTRACT

This study examines the effect of practical work on students' understanding in physics. Seventy two second year students of St. Rose's Senior High School-Akwatia in the Denkyembour District in Eastern Region were purposively sampled into experimental and control groups. The experimental group was taught using practical work as instructional technique and the control group using the traditional method for teaching. The major objectives of the study were to find out; the effect of practical work on students' performance in physics, the effect of practical work on students' attitude towards the study of physics, the effect of practical work on students' acquisition of science processes, the perception of students on the use of practical work as instructional strategy in physics. Four research questions and two hypotheses were raised in the study. The instruments used for the study were pre-test and post-test, practical activities and questionnaires for both the experimental and control groups. Data collected were analysed using z-test, t-test and descriptive statistics. The findings revealed that students exposed to frequent practical work performed better than those exposed to traditional method of teaching. The study recommends that physics teachers take students through a lot more practical activities, since this will help students gain better understanding of the concept and improve their academic performance.

CHAPTER ONE

INTRODUCTION

1.1: Overview

This chapter comprises background of the study, statement of the problem, purpose, and significance of the study, research questions, the research hypotheses, limitation and delimitation.

1.2: Background of the study

Science is perhaps unique as a subject in the curriculum of schools all over the world. This uniqueness results from the variety of materials and practical work necessary for its effective teaching. Most other subjects can be learned if common tools for teaching are available, such as pencil, paper, blackboard, textbooks and a few supplementary aids. These are also essential for the teaching of science but, if they are the only tools, science becomes a dull and uninteresting subject.

If science is to be learned effectively it must be experienced. It must be learned and not learned about. Science is so close to the life of every boy and girl that there is no need to confine its study to the reading of textbooks or listening to lectures. Wherever you may go in the world, science is an intimate part of the environment living things, the earth, the sky, air and water, heat and light and forces such as gravity. No teacher needs ever be without first-hand materials for the study of science.

The main difference between science learning and other school subjects is that it involves practical work- where students are made to perform some activities, observe, record data and discuss the data from the activities. This is normally done to enhance the understanding of a taught concept or to explain phenomenon in the real world. Physics is an empirical subject.

Everything we know about the physical world and about the principles that govern its behaviour has been learned through observations of the phenomena of nature. The ultimate test of any physical theory is its agreement with observations and measurements of physical phenomena.

Demonstrations and practical work in the laboratory have long been accepted as an integral part of learning physics (Wellington, 1998; Trumper, 2003) and it is hard – even impossible – to imagine as reasonable the possibility of physics teaching without experimental work. Many reforms of physics education have relied on the conviction that learning can be improved through developing ways in which experiments are conducted in the physics classroom as well as by developing suitable study material and experimental models of teaching (Duit & Confrey, 1996). The reformers and designers of science curricula have quite often drawn support for their ideas from constructivist views of learning (Trumper, 2003; Niaz et al., 2003).

Practical activities have a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging students in science laboratory activities (Pickering, 1980; Hofstein & Lunetta, 1982; Garnet & Hackling, 1995; Lunetta, 1998; Tobin, 1990; Hofstein & Lunetta, 2004).

The common constructivist core is a view of human knowledge as a process of personal cognitive construction, or invention, undertaken by the individual who is trying, for whatever purpose, to make sense of her social or natural environment (Taylor, 1993). In other words: knowledge is not viewed as some sort of a true copy of features of the world outside but as construction of the individual. Knowledge acquisition (i.e. learning) is not the transfer of "nuggets of truth" as Kelly (1955, p. 47) puts it, but a personal construction by the individual. The learner is not seen as a passive receiver but as an active constructor of knowledge. Since the end of the 19th century, when schools began to teach science systematically, the science laboratory has become a distinctive feature of science education.

During the major curriculum reforms in science education in the early 1960s, practical work in science education was used to engage students in investigations, discoveries, inquiries, and problem-solving activities. In other words, the laboratory became (at least in the minds of science educators and curriculum developers) the centre of science teaching and learning.

Since then science, particularly physics has come to be taught with great emphasis on practical activities. There are two underlying reasons for this movement. First, science is considered more than a body of knowledge to be learned. In fact science belongs in the school laboratory as naturally as cooking belongs in a kitchen and gardening in a garden. It follows that the process skills of science are considered equally important and that teaching physics should equally emphasize the development of practical skills by using a range of process skills in experimental work in physics classrooms. Second, the current constructivist view of learning which consider learning as an active participation on the part of the learner. The learner is considered as an individual who actively constructs his/her knowledge base by engaging in learning activities.

Therefore practical work in physics education is expected to provide students with opportunity to construct scientific knowledge based on personal involvement in designing experiments, manipulation of data, observations of outcomes and making inferences and generalisations.

Among the sciences, physics is considered a fundamental subject (Wenham, Dorling, Snell & Taylor, 1984). It imbues learners with systematic thinking and supplies the theories necessary for understanding the mechanics of how the things mankind relies on work. It provides students with analytical, problem solving and quantitative skills which are important for many sciences. Physics prepares students to synthesize and analyze data and to present their findings in understandable formats. Systematization of the scientific problem solving technique is employed. The link between physics and other sciences is profound. It continues to expand tremendously in the contemporary world. All technology is beholden to physics due to its emphasis on addressing phenomena involving the interaction of matter and energy. This interaction is necessary for the technological needs of the changing society (Juceviciene & Karenauskaite, 2004; Zhaoyao, 2002). Physics continues to influence applications in medicine. Medical methods including imaging techniques (X-rays, CT-scanning, ultra-sound echo techniques, MRI techniques) and diagnostic patient screening techniques (Freeman, 2012) are based on physics principles. Currently, a wide variety of treatment techniques made possible by the discovery of radioactivity and other high frequency radiations exist. The unravelling of the DNA structure and the subsequent genome project required a significant input from physics techniques (Stanley, 2000). Continuing research into challenges posed by diseases such as cancer, Ebola, and HIV/AIDS, will require the development of high precision equipment employing physics principles. The current fixation with information communication technologies (ICTs) could not have occurred without the primal physics discovery of the transistor. Computers, mobile phones and their attendant spin-off technologies show the indispensability of physics. Photonics and other quantum nanostructures show promise in terms of optical fiber based communication systems (Sharma, Rohilla & Manjunath, 2005). Laser applications are used in commerce and industry. Electromagnetism is vital in the generation of electricity, mobile phone communication, optical and satellite communication, portable electronics, radio and radar perception, and X-ray crystallography (Campbell, 2006).

Hence the researcher recognises the need to introduce students to more practical works during instructional periods. This would help students understand basic concepts in physics which would influence their performance in senior high school physics. Students understanding basic concepts in physics will help them apply this knowledge in their daily life activities.

1.3: Statement of the problem

This study is a direct response to the deteriorating performance of students in Physics in the West African Senior School Certificate Examinations (WAEC Chief Examiners Report, 2011). According to Garwin and Ramsier (2003), interest in high school physics is decreasing, learning motivation in physics is declining, and the examination results are getting worse. This situation does not favour Ghana's move towards developing a scientific and technological nation.

The poor performance was occasioned by lack of relating basic theories in physics to everyday natural occurrences. Despite the importance of Physics to the scientific and technological development of our nation, understanding of the subject had dwindled over the years and performance of the enrolled students had not been encouraging as indicated by Buabeng, Ossei-Anto and Ampiah, (2014). Many students consider physics as difficult, abstract and theoretical (Buabeng & Ntow, 2010). This is because many schools in the country do not allot much time for practical work. The subject is considered devoid of applications in the day to day life, hence students find the subject boring and unenjoyable. Therefore, this study aimed at finding out the effect of practical works on students' understanding of some physics concepts.

1.4: Purpose of the Study

The purpose of this study was to find out the impact of practical work on students' understanding of some physics concepts. The research was also motivated in part by the growing incidence of failure in physics at the senior high school certificate examination as a clear manifestation of poor teaching and learning strategy. It has also been revealed that poor performance among students in Physics is partly due to lack of interest in the subject by students (Buabeng et al., 2014), hence the study also explored the effect of students' attitude towards practical work in physics in the senior high schools. Most researches on practical work in physics have proved to having the potential of making learners to remember information longer and to be able to use them more effectively because the students build their own knowledge as they follow the experimental procedures (Kibett & Kathuri, 2005). In this light, the researcher also assessed the science process and practical skills acquired by the students as a result of performing practical work during the study. The research also aimed at investigating the effectiveness and integration of practical work in the teaching and learning of physics at the senior high schools and how it can also be incorporated as a teaching method in other science subjects in the country.

1.5: Research Objectives

The specific objectives were to investigate into:

(i) The effect of practical work on students' performance in physics.

(ii) The effect of practical work on students' attitude towards the study of physics.

(iii) The effect of practical work on students' acquisition of science processes.

(iv) The perception of students' on the use of practical work as instructional strategy in physics.

1.6: Research questions

The study addressed the following research questions:

(i) What is the effect of practical work on the experimental group's performance in physics?

(ii) What is the effect of practical work on the experimental group's attitude towards the study of physics?

(iii) What is the effect of practical work on the experimental group's acquisition of science process skills?

(iv) What is the perception of the experimental group about the use of practical work in the study of physics?

1.7: Research hypotheses

This research addressed the following hypotheses;

1. There is no significant difference in performance between the students in the experimental group taught using practical work and the control group students who were taught through the traditional method.

2. There is no significant difference in attitude change towards the study of physics between the experimental group and the control group

1.8: Educational Significance of the Study

The main educational importance of this research is to gather appropriate experimental strategies and methodologies to help solve the problem of poor performance among students in physics and also assist students to link theories with natural phenomenon. It also assesses using regular practical work as teaching strategy in improving students' understanding of concepts in physics. This research could be a resource for teachers and schools who want to improve teaching and learning of physics in their schools. The outcomes of the study could provide a source reference for curriculum developers, other researchers and educators who wish to research issues on how practical work may be used to help to improve students' learning and understanding of concepts in physics and other related science disciplines.

1.9: Delimitation of the study

The study was delimited to only the first year elective science students in St. Rose's Senior High School because it is believed that most of these students have not been exposed to much practical lessons (if any) in science or physics at the Junior secondary school level. It is also the nearest science resource centre school where most needed and appropriate instructional materials were obtained for use by the researcher.

1.10: Limitation of the study

A broader survey of the study would have clarified to a large extent the effectiveness of practical work on students' understanding of physics concepts. Time and cost constraints prevented the extension of this study to other institutions. Therefore, the results of the study would be strictly applicable to the elective science students in St. Rose's Senior High School.

CHAPTER TWO

LITERATURE REVIEW

2.1: Overview

This chapter discusses the available literature related to this study. It is grouped under the following headings: Introduction, The SHS Physics syllabus, Physics as a practical subject, the nature of practical work, the effect of practical work on students, Students' attitude towards science, as well as students' attitude to science and practical work.

2.2: Introduction

In order for students to understand new ideas or concepts and construct their own knowledge, they need to see clear examples of what the new ideas or skills represent (Rosenshine, 1997; Trowbridge, Bybee & Powell, 2000). Furthermore, in learning new materials or skills, students should be given extensive opportunity to manipulate the environment (Joyce, Weil & Calhoun, 2000) as, according to Piaget (1978), students' cognitive structures will grow only when they initiate their own learning experiences. For example, Rosenshine (1997) suggests that teachers should provide tasks where students can engage in cognitive processing activities of organising, reviewing, rehearsing, summarising, comparing, and contrasting with other students, or with the teacher or working alone. In addition, teachers should encourage informal discussions and structure science activities so that students are required to explain and justify their understanding, argue from the data, justify their conclusions and critically assess the scientific explanations of a matter (Abrams, 1998).

Whilst the value and purpose of practical work has been continuously debated, it has nevertheless remained a core component of school science education. Indeed, the inclusion of practical work within an academic subject is a significant feature that distinguishes science from the majority of other subjects in secondary schools (Sharpe, 2012). The use of practical work in schools is clearly recognised as important, yet remains rather a typical in terms of the quantity and amount of time devoted to it compared to some other countries (Bennett, 2005; Woolnough, 1998). For most teachers, practical work encompasses what teaching and learning science is all about (Woodley, 2009).

As Abrahams and Millar (2008) indicate, many teachers view practical work “as central to the appeal and effectiveness of science education” (p. 1946). Indeed, reference is often made to the adage, ‘I hear and I forget, I see and I remember, I do and I understand’ written originally by Confucius (as cited in Sharpe, 2012, p. 26). Klassen (2009) indentifies three essential aspects, which could be generalised to most pupil oriented science experiments; (1) exposing the difficulty in obtaining experimental results if the scientific method behind the experiment is strictly followed, (2) dealing with the difficult nature of the science behind the experiment, and (3) establishing the experiment outcome.

Through practical work, the pupils’ knowledge and understanding of science is likely to be increased (Wellington, 2005), but it is important to distinguish between “knowledge”, “knowledge how” and “knowledge why”. Engaging in practical activities improves pupils’ knowledge of what happens and how it happens, but not also why it happens. Understanding why is not the pupils’ “discovery” behind the experiment, but self-reflecting on the experimental work already done.

Learning through practical work and experience is very important in science lessons. Research on the effect of using live animals in the classroom on pupils’ perception of the animals showed that, in comparison to other approaches, pupils get a better attitude and long-lasting knowledge about the living organisms (Tomažič, 2009), they experiment without the teacher’s intervention (Tomkins & Tunnicliffe, 2001) and also invent and unify their own terminology while reporting on the experiment. In general, pupils are intrinsically motivated towards learning, but not also for explaining abstract experimental observations (Juriševič, Glažar, Pučko & Devetak, 2008). Pupils show interest in more concrete content, while abstract content gives rise to anxiety.

For effective learning to occur, teachers should first identify students' prior ideas, make students aware of them and, in the light of these ideas, help students construct their own understanding by allowing them to practice them. After that teachers should provide opportunities for students to apply their newly acquired knowledge to different situations.

2.3: The SHS Physics syllabus

A quick review of the Ministry of Education Physics syllabus for senior high schools in Ghana reveals the rationale behind the teaching of Physics in senior high schools. The rationale is to help students acquire scientific knowledge and be able to apply them in the scientific and technological advancement of the country. Among the aims of the syllabus is to:

1. Provide, through well designed studies of experimental and practical physics, a worthwhile hand on educational experience to become well informed and productive citizens.
2. Enable the Ghanaian society function effectively in a scientific and technological era, where many utilities require basic physics knowledge, skills and appropriate attitudes for operations.
3. Recognise the usefulness, utilization and limitations of the scientific methods in all spheres of life.
4. Develop in students, skills and attitudes that will enable them to practise science in the most efficient and cost effective way.

5. Develop in students' desirable attitudes and values such as precision, honesty, objectivity, accuracy, perseverance, flexibility, curiosity and creativity.
6. Stimulate and sustain students' interest in physics as a useful tool for the transformation of society. (Ministry of Education, 2010, p. ii)

The syllabus is divided into seven main sections, covering introductory physics and properties of matter, mechanics, thermal physics, waves, electricity and magnetism, atomic and nuclear physics, and electronics. A total of six periods per week is what the syllabus specifies, with each period constituting a total time of 40 minutes. Four teaching periods are allocated for theory and two periods for practical section in every week. The researcher sees the two periods allotted for the practical session as insufficient for students to manipulate equipments and materials as they try to investigate the theory thought them in class. However, according to anecdotal evidence collected during the researcher's interaction with some teachers and students, teachers do not even use the two periods allotted for the practicals. Teachers use the two periods in teaching theory. Some of the reasons are lack of time to complete the syllabus, since most teachers focus on preparing students for the final exams and practical session is time consuming.

The physics syllabus, however, noted that three periods can be allocated for practical sessions in schools were such arrangement can be possible. The syllabus defines practicals as the demonstration of the inquiry processes in science and refers to skills in planning and designing of experiments, observation, manipulation, classification, drawing, measurement, interpretation, recording, reporting, and conduct in the laboratory/field. It aims to develop students in:

1. **Making observation, raise questions and formulate hypothesis:** The students should be able to:

I. Observe the world around them from a scientific perspective.

II. Pose questions and form hypothesis based on personal observation, scientific articles, experiments and knowledge.

III. Read, interpret and examine the credibility and validity of scientific claims in different sources of information such as scientific articles, advertisements or media stories.

2 Design and conduct investigations: The students should be able to:

I. Articulate and explain the major concepts being investigated and the purpose of an investigation.

II. Select required materials, equipment and conditions for conducting an experiment.

III. Identify independent and dependent variables.

IV. Write procedures that are clear and replicable.

V. Employ appropriate methods for accurately and consistently

   a. making observations

   b. making and recording measurements at an appropriate level of position

   c. collecting data in an organized way.

VI. Properly use instruments, equipment and materials (such as scales, metre rule, stop watches) including: set-up, technique, maintenance and storage.

VII. Follow safety guidelines.

3 Analyze and interpret results of scientific investigations: The students should be able to:

I. Present relationships between variables in appropriate forms:

II. -represent data and relationships between variables in charts and graphs

III. use appropriate technology and other tools

IV. Use mathematical operations to analyze and interpret data results.

V. Identify reasons for inconsistent results, such as sources of error or uncontrolled conditions, and access the reliability of data.

VI. Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.

VII. State questions raised by an experiment that may require further investigation.

4 **Communicate and apply the results of scientific investigation:** The students should be able to:

I. Develop descriptions and explanations of scientific concepts that an investigation focuses on.

II. Review information, explain statistical analysis and summarize data collected and analyzed from an investigation.

III. Explain diagrams and charts that represent relationships of variables.

IV. Construct a reasoned argument and respond appropriately to critical comments and questions.

V. Use language and vocabulary appropriately: speak clearly and logically and use appropriate technology and other tools to present findings.

VI. Use and refine scientific models that stimulate physical processes or phenomena. (Ministry of Education, 2010, p. ix)

This shows how the syllabus intends to use practical work to enhance students understanding in physics and how to make them acquire scientific knowledge. The next section looks at reviews of Physics as a practical subject.

2.4: Physics as a practical subject

Physics is, by nature, a hands-on (doing) and minds-on (thinking) inquiry-based discipline. Practical work is therefore normally seen as essential in the study of physics. The study of physics require students acquiring science process skills such as manipulative skills, observation skills, experimental and interpretive skills, planning skills as well as developing attitudinal characteristics such as persistence, cooperation and enthusiasm. All these can be achieved through practical activities. Hanif, Sneddon, Ahmadi and Reid (2009) found that university students in Scotland felt that practical work improved their science process skills and their ability to understand theory. For more than a century, practical work activities have played a central and distinctive role in physics education (Hofstein & Lunetta, 2003). However, these authors remarked that for many students the practical work is mainly manipulating equipment (doing) but not manipulating ideas (thinking).

During the major curriculum reforms in physics education in the early 1960s, practical work in physics education was used to engage students in investigations, discoveries, inquiries, and problem-solving activities. In other words, the laboratory became (at least in the minds of science educators and curriculum developers) the centre of science teaching and learning. For example, George Pimental editor of the CHEMStudy (summarized by Merril & Ridgway, 1969) suggested that the laboratory was designed to help students gain a better idea of the nature of science and scientific investigation by emphasizing the discovery approach.

In addition, he suggested that it gives students an opportunity to observe science and to gather data useful for the development of principles subsequently discussed in the textbook and in class. However, when it came to assessing and evaluating the effectiveness of the laboratory, the situation was less simplistic and less clear. For example, Ramsey and Howe (1969) in an extensive review of the literature regarding instruction in the science laboratory concluded that:

The experience possible for students in the laboratory situation should be an integral part of any science course has come to have a wide acceptance in science teaching. What the best kinds of experiences are, and how these may be blended with more conventional class work has not been objectively evaluated to the extent that clear direction based on research is available for teachers. (p.75)

Watson, Prieto and Dillon (1995) showed that practical work in the laboratory has only marginal effects on students' understanding of physics. In the quest for finding efficient way of teaching physics in schools, many educators such as Lunnetta, Hofstein and Giddings (1981), Pickering (1980) and Walberg (1991) begun to ask whether practical experiences contribute to anything unique and important enough to justify their expense and time. Bates (1978), while pursuing the sane questions, had concluded from a review of studies involving practical work that though demonstration, lecture and practical teaching methods appear equally effective in transmitting physics content, practical experiences are superior for providing students with skills in working with equipment, and have a greater potential for nurturing positive students' attitudes and for providing wider a wider variety of students with opportunities for success in physics. Okebukola (1986) emphasized that the effectiveness of practical work in physics teaching is indispensable. He further states that the boredom reportedly experienced by students in practical sessions is just indicative of poor organisation, management and coordination of practical activities by teachers.

2.5: The nature of practical work

The fundamental purpose of much practical work is to help students to make links between two domains: the domain of objects and observables (things we can see and handle) and the domain of ideas (which we cannot observe directly) (Millar, 2009).

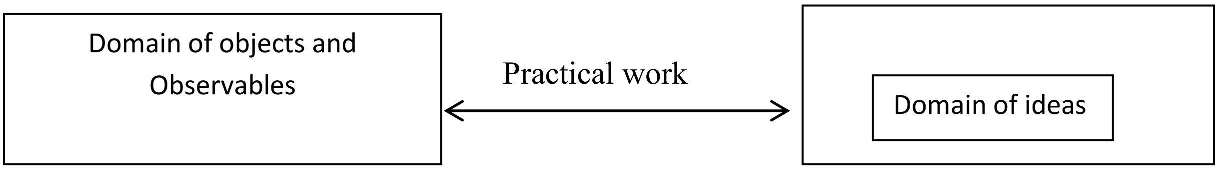

Figure1: **Practical work: Helping students to make links between two domains (Tiberghien, 2000)**

In some practical works, the domain of ideas plays a relatively minor role. For example, we may simply want students to examine an object, or a substance, or an event, and observe and commit to memory some things about it. In other practical activities, however, we want students to develop their understanding of particular scientific ideas that are significant for describing or explaining the observations made. In these activities, thinking is at least as imperative as doing and seeing; students learn only when the activity is not only 'hands on' but also 'minds on'.

Practical activities that sturdily engage the domain of ideas have a considerably higher learning demand (Leach & Scott, 1995) than those which simply aim to allow students to see and remember an observable event. In such activities, students are likely to need help to use or develop the ideas that make sense of the activity, and lead to learning. Activities that have this kind of 'scaffolding' built into their plan are likely to be more effectual than ones which do not.

Several studies suggest that practical activities, whose central aim is to assist students develop their knowledge and understanding of the natural world, vary significantly in learning demand. If the purpose is for students to examine an object, or material, or event that they have not seen before, or not looked at directly before – and to remember what they see – then the learning demand is comparatively low. Many students will remember it for some time; the more astonishing or remarkable the observation is, the longer they are likely to commit to memory. But if the objective is to help students develop their understanding of descriptive ideas, concepts, models or theories, then the learning demand is much greater.

To a large extent practical work is somewhat ineffective because teachers underrate the challenge the students face in making sense of what they see. The thought that explanations 'emerge' from observations has been called 'the fallacy of induction' (Driver, 1983). We might anticipate that activities of high learning demand would be planned or presented in class in ways that reflected this; a recent study, however, found little difference in the way activities of higher and lower learning demand were designed or presented (Abrahams & Millar, 2008).

The way teachers use practical activities whose main intent is to help students develop their understanding of scientific enquiry, often seems to imply a belief that 'practice makes perfect' – that students will get better at designing and conducting their own investigations simply through practice. Research, however, tends to show that more effective learning occurs when specific aspects of scientific enquiry are identified and taught (Watson, Wood-Robinson, & Nicolaou, 2006; Millar, 2009). Millar (2009) suggests any given practical activity can be presented in a variety of ways. Significant components of presentation are: how students understand the reason for the activity, how it is explained to them, what discussion precedes or follows it, and how it is recorded. The approach a practical activity is presented can have a considerable effect on its effectiveness in learning terms. One feature of the presentation of an activity to students is their awareness of its purpose: can they see why they are doing it? On the foundation of their current understanding, can they grasp what it is about? Is it a way of answering a question they are already thinking about, or of exploring an issue they have become interested in or is it just what the teacher has told us to do today?. In this light teachers are to know how to design and present practical work to their students in order to achieve the aims and objectives for the practical work.

2.6: The effect of practical work on students

Many researchers believe that practical work play an important role in learning science, but the reasons for its importance are less clear. This lack of clarity lies in the vagueness of the questions asked about the role of practical work. Asking about the importance of practical work for learning science is like asking whether children learn by reading. The answer lies in the nature and contents of the activities and the aims which they are trying to achieve.

Freedman (1997) investigating the impact of a hands-on science programme on attainment and attitudes reported that: Students [aged 14-15] who had regular laboratory instruction (a) scored significantly higher ($p < .01$) on the objective examination of achievement in science knowledge than those who had no laboratory experiences; (b) exhibited a moderate, positive correlation ($r = .406$) between their attitude toward science and their achievement; and (c) scored significantly higher ($p < .01$) on achievement in science knowledge after these scores were adjusted on the attitude toward science co variable.

McSharry and Jones (2000) suggest that merely explaining to students about their environment may not be the best method for helping them to gain an understanding of why it is there or how the processes at work in the environment have formed it. However, role-plays, such as those describing predator–prey relationships or antibody–antigen interactions, can give students a chance to experience these events in a physical way, which may be more appropriate to their personal learning style. As a result, students can understand abstract and difficult topics that are not always visible phenomena. Indeed, Fadali, McNichols and Robinson, (1999) point out that role-playing may be useful in secondary science classes as a way of introducing and familiarising students with difficult, abstract or complex concepts in biology and the physical sciences. Finally, Maier (2002) argues that teachers, trainers or supervisors favour role-play as a handy means of enlivening the learning content; in particular, this model brings forth detailed and concrete study materials which are more difficult to pinpoint by the way of lecture and discussion.

A survey conducted by NESTA (2005), suggests that 99% of the sample of science teachers interviewed believed that enquiry learning had a (83% - *'very'*; 16% - *'a little'*) major effect on student performance and achievement. However, the role of processes in science education have been contested: some science educators have challenged that practical work might help students to understand how scientists work, while others have argued that a process-based approach (that is, an approach that focused on experimental skills) was likely to lead to better understanding of science concepts (Donnelly, Buchan, Jenkins, Laws & Welford, 1996). Meaning can only be formed in students' minds by their own active efforts (Saunders, 1992) and cannot be created by someone else for students. This suggests that students are not simply passive recipients of information from the teacher, computer, textbook or any source of information during the learning process. They have to wrestle with an idea in their own minds until it becomes meaningful to them. This can only be achieved by exposing them to practical activities.

An analysis carried out by Kind (1999) of the TIMSS data by comparing the scores of 13-year-old students from England, Norway and Portugal. He observed that the three countries have different traditions of investigative work and Kind argues that although students in English schools did better at practical tasks than did the children from Portuguese schools that the results may be related as much to the type of practical work as to the quality.

Evidence of successful practice in the use of practical work comes from White and Gunstone's (1991) study which indicates that students must manipulate ideas as well as materials in the school laboratory. Engaging learners in practical work will help them develop important skills such as critical thinking and will be able to analyse and interpret experimental data; it will also help them to understand the process of scientific investigation, and develop their understanding of science concepts. Physics practical experiences help students to acquire understanding of how to avoid hazard, risk and improve their ability to work safely. Students need to understand something about the nature of science if they are to appreciate the limits and value of practical activities. The teachers' role in helping students to compare their findings with those of their peers and with the wider science community is critical (Driver, 1995).

Some researchers have reported that practical work can increase students' sense of ownership of their learning and can increase their motivation (Johnstone & Al-Shuaili, 2001). Thompson and Soyibo (2002), in a comparison study, reported positive impacts of a combination of lectures, teacher demonstrations, discussion and practical work on Jamaican 10th grade [age 15-16] students' attitudes to chemistry and understanding of electrolysis.

As Lunetta., Hofstein and Clough (2007) put it, 'learners construct knowledge by solving genuine, meaningful problems' (p. 405). These findings suggest that practical activities which have no context and are simply set up to practise skills or for assessment purposes, may generate lower quality performance than tasks which appear to students to have a purpose connected to their daily lives.

Practical work gives students the opportunity to exchange views and share personal experiences, this produces the 'cognitive conflict' that is fundamental to intellectual development. In order to foster cognitive conflict, students need opportunities to pose questions about science, to work with others, to conduct investigations, present and defend their ideas, solutions, and findings, and assess their own and other students' reasoning (Pope & Gilbert, 1983).

Barron *et al.* (1998), working with 5th grade students in the US describes a process of designing, implementing, and evaluating problem and project-based curricula. They describe four design principles that lead to positive effects on student learning: (a) defining learning-appropriate goals that lead to deep understanding; (b) providing scaffolds such as 'embedded teaching', 'teaching tools', sets of 'contrasting cases', and beginning with problem-based learning activities before initiating projects; (c) ensuring multiple opportunities for formative self-assessment and revision; and (d) developing social structures that promote participation and a sense of agency. Barron *et al.* (1998) point out that:

A major hurdle in implementing project-based curricula is that they require simultaneous changes in curriculum, instruction, and assessment practices-changes that are often foreign to the students as well as the teachers.

Adey, Hewitt, Hewitt and Landau, (2004) also promote the value of cognitive conflict, meta-cognition and bridging from concepts to new situations and provide substantial evidence of the impact of cognitive acceleration through science education on science attainment. The success of the CASE and CAME programmes (aimed at pupils aged 11-13) point to the need for any innovation to be supported by classroom-focused coaching and modelling which involves at least 20-30 hours of professional development. Such approaches provide teachers with opportunities to engage students in activities which are minds on as well as hands-on (Gunstone, 1991). The role of teachers in scaffolding learning – that is, sequencing complex ideas and experiences (Lunetta *et al.*, 2007).

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

Other evidence of the long-term effects of practical activities comes from a study by Gibson and Chase (2002) who studied the impact of a summer science Exploration program (SSEP), a 2-week inquiry-based science camp in Massachusetts, US. The camp was designed to stimulate interest in science and scientific careers among middle school students. The science opinion survey and the career Decision-making Revised surveys were taken by 79 SSEP students and 35 students who applied but were not accepted. The authors report that the interviews and surveys suggested that SSEP students maintained a more positive attitude towards science and a higher interest in science career than students who applied to the program but were not selected. Millar (2004) identifies the value of practical activities in school science.

More specifically, practical work is essential for giving students a 'feel' for the problematic of measurement, and an appreciation of the ever-presence of uncertainty (or measurement error). It is also an important tool for teaching about experimental design. Indeed research suggests that students design better investigations when they actually carry them out than when only asked to write a plan; feedback from experience improves design (APU, 1988).

However, he adds a note of caution when he comments on the success of scaling up innovations across an education system: There are few examples of the successful implementation of extended practical projects or investigations as part of the science curriculum in the context of 'mass education', where large numbers of teachers and students are involved. Teachers find it hard to devise or to help students to create enough project ideas, year on year. It is simple for the activity to become routines, and become something very different from what was initially envisaged when it was included in the curriculum.

Summing up the findings of their recent review of research into practical work, Lunetta *et al.* (2007) conclude: When well planned and effectively implemented, science education laboratory and simulation experiences put students' learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other subject education experiences.

They explain further that the laboratory can be an environment particularly well suited for providing a meaningful context for learning, determining and challenging students deeply held ideas about natural phenomena, and constructing and reconstructing their ideas' (Lunetta *et al*., 2007). In terms of instructive approach, they argue that: Social learning theory makes clear the importance of promoting group work in the laboratory so that meaningful conceptually focused dialogue takes place between students as well as between the teacher and student.

An increased focus on the use of informal contexts for science education is evident in the UK. A review of the literature on outdoor education by Rickinson *et al.* (2004) concluded that:

1. Substantial evidence exists to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners' opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom.

2. Specifically, fieldwork can have a positive impact on long-term memory due to the memorable nature of the fieldwork setting. Effective fieldwork and residential experience in particular, can lead to individual growth and improvements in social skills. More importantly, there can be reinforcement between the affective and the cognitive, with each influencing the other and providing a bridge to higher order learning.

3. Despite the substantial evidence of the potential of fieldwork to raise standards of attainment and improve attitudes towards the environment there is evidence that the amount of fieldwork that takes place in the UK and in some other parts of the world is severely restricted, particularly in science.

4. The number of studies that address the experience of particular groups (e.g. girls) or students with specific needs is negligible, although those that have been done draw

conclusions that are important in terms of both policy and practice. Some children are more likely to take part in fieldwork than others for a range of reasons, many of which could and should be addressed.

5. A minority of studies provide a health warning to proponents of outdoor education. Poor fieldwork is likely to lead to poor learning. Students quickly forget irrelevant information that has been inadequately presented.

The specific impact of practical work during fieldtrips has received little study and much of the literature reports on attitudinal impacts rather than on conceptual development. There are some exceptions, though, for example, in a recent study, Prokov, Tuncer and Kvasničák, (2007) found that a one-day field-trip resulted not only in significant and positive increases in 11-12-year-old Slovak students' attitudes toward biology, the natural environment outside and future careers in biology but that students displayed a better understanding of ecology concepts like ecosystems and food webs.

Practical work brings in behaviour changes in the students. The scientific temperament, curiosity, interest and creativity form the basis of this change. Practical work attempts to provide a body of knowledge through procedures that are demonstrated.

2.7: Students' attitude towards science

There has been an ongoing spotlight in trying to understand students' attitudes to science within science education research, along with the struggle to actually define and differentiate these attitudes towards science (Zain, Rohandi, Jusoh & Samsudin, 2010). Combined with research indicating widespread scientific ignorance in the general populace (Durant & Bauer, 1997; Durant, Evans, & Thomas, 1989), and an increasing recognition of the importance and economic utility of scientific knowledge and its cultural significance, the falling numbers choosing to pursue the study of science has become a matter of considerable societal concern and debate (for example, House of Lords 2000; Jenkins, 1994). Consequently, the promotion of favourable attitudes towards science, scientists and learning science, which has always been a component of science education, is increasingly a matter of concern.

Chen and Howard, (2010) have suggested the potential links between positive student attitude and its influence on continued participation and attainment. It could be understood that positive attitudes towards science may mean students are more inclined to participate and/or be more motivated to achieve.

The term attitude is a concept that is not easily definable. White (1988) has commented on how the term is rather ambiguous both in the psychological and the everyday sense of the word. There have since been attempts to define attitudes, but these seem to be rather specifically related to individual research objectives and thus restricting transferability to other studies. An early notable contribution towards its elaboration was made by Klopfer (1971), who categorized a set of affective behaviours in science education, as:

1. The manifestation of favourable attitudes towards science and scientists;
2. The acceptance of scientific enquiry as a way of thought;
3. The adoption of 'scientific attitudes';
4. The enjoyment of science learning experiences;
5. The development of interests in science and science-related activities; and
6. The development of an interest in pursuing a career in science or science related work.

Gardner (1975) has often been referred to as providing clarity over terms relating to attitudes towards science. Gardner (1975) explained how an attitude always consists of a specific 'attitude object' which stimulates the subjective response. It has been largely agreed that an attitude is held intrinsically within the individual, and thus, is inaccessible to direct observation. However, it is observable on the basis of a measurable response to an attitude stimulus (Ajzen & Fishbein, 2005). An 'attitude object' or stimulus can be anything that can be distinguished and considered by anyone.

The 'attitude object' can be concrete, abstract, inanimate, people or groups, and it may involve any form of information that possesses evaluative implication (Bohner & Wänke, 2002). Attitudes are private and specific to individuals, organised through single or multiple experiences, and influence actions to be completed by the person either intrinsically or extrinsically (Rajecki, 1990). As a result it is very difficult to effectively measure attitude of individuals. Attitudes can be prescriptive or evaluative and not universally accepted, such as 'we should do more practical work' or 'practical work is a waste of time'. They are also descriptive, such as 'practical work requires the use of a lot of scientific skill'. These propositions can influence a positive or negative association: a student may dislike learning scientific skills in which case the previous comment would be spoken negatively and likewise, the reverse is true. The same descriptive proposition held by two students can influence opposing attitudes (White, 1988). Generally propositions that are acquired through direct experience or social transmission are of a more stable nature (Greenwald, 1989) because students are able to personally engage with the issue, thus potentially increasing predictability in behaviour when measuring their attitudes.

2.8: Students' attitude to science and practical work

Most educators have the same opinion that teaching should build on the interests and experiences of students. Experiences and interests among learners vary, and there is comparable difference in what can be considered appropriate and useful knowledge for students from diverse life situations. Haussler and Hoffmann (2002) quote results from the ROSE survey showing that students' interest in physics declined during Secondary Level I. This lack of interest in science often manifests itself when students are at an age when they are permitted to make their own curricular choices (Sjøberg, 2002). The above findings raise serious questions about the implementation of changes made in science curricula regarding the development of students' interest in science.

Lee and Fradd (2001) found out that most science, especially physics lessons fail to relate theories to actual life situations, thereby making the class boring for students. Establishing connections between theories and daily life activities through the use of practical work requires teachers to not only incorporate the types of knowledge that are used in the class but also to understand how that knowledge can be used to achieve a set of greater goals or purposes in everyday life activities (González & Moll, 2002). The challenge then is to create learning environments with connected meaning for students, which requires identifying powerful links bridging students' knowledge with classroom instruction. Gunstone and Champagne (1990) argued that practical work could successfully be used to promote conceptual change if small qualitative laboratory tasks are used.

Studies have made known the influence of methods of instruction on students' attitude towards science. Kempa and Dube (1974) worked on the influence of science instruction; the result was that attitude becomes more positive after instruction. Long (1981) also concluded that diagnostic-prescriptive treatment promotes positive attitude. Hough and Peter (1982) also said that groups that scored significantly high in science achievement test also scored significantly high in attitude test. Steven and Atwood (1978) in a study on the relationship between interest and achievement found that science interest was significant at 0.05 level as predictors of science progress scores. Simpson and Wasik (1978) also supported the view of predictability of achievement from the knowledge of attitude.

The studies thus reviewed suggest that there is a relationship between attitude and methods of instruction and also between attitude and achievement; and that it is possible to predict achievement from attitude scores. What is needed to complement the results of such studies however is the nature of relationship between students' attitudes and practical work.

A lot of studies in the last two decades have examined students' attitudes towards science in science education (Osborne, Simon & Collins, 2003). The significance of researching students' attitudes towards science has been highlighted by the Organisation for Economic Co-operation and Development (OECD, 2010) who deem that a student's 'scientific literacy' should consist of certain attitudes, beliefs which by possessing and utilising effectively, it is believed, will help the individual, the society and worldwide. Yet the significance of attitudinal research, primarily attitudes towards science, is not a recent area in science education. Work on attitude measurement instruments such as the Likert scale along with theoretical ideas influenced the research into attitudes towards science which by the 1960s had become something of a regularity (Koballa & Glynn, 2007). Indeed, The Dainton Report (2006) emphasized the issue regarding scientific attitudes moving away from science and by the mid-1970s, Ormerod and Duckworth (1975) began researching into students' attitudes to science.

During the 1990s, some science educators (Freedman, 1997; Thompson & Soyibo, 2002) reported in studies that practical work was a central means for enhancing attitudes, inspiring interest and enjoyment, and motivating students to learn science.

Additionally, it has been argued by Hofstein and Lunetta (2004) that hands-on activities are likely to enhance positive attitudes and cognitive growth. Though, as stressed by Abrahams (2009), some studies (Beatty & Woolnough, 1982; Kerr, 1963) that have articulated such positive perspectives of practical work, have concentrated more on the rhetoric through questionnaires on students' views, than the actual reality of practice and behaviour of students. However, White (1988) assumes the position that an attitude relating to science must be the incorporation of the individual's beliefs, behaviour and emotions relating to the stimuli and hence, as Bagozzi and Burnkrant (1979) consider, the view that an attitude is the interplay of the affective, cognitive and behaviour domains, an attitude to science is acknowledged by White (1988) as this combination, the tripartite model.

A study by Kim and Song (2009) separated conventional instruments of an attitude towards science into intrinsic (related directly to students) and extrinsic (related to social viewpoint). They established intrinsic attitudes towards science, like 'school science is easy', influenced students' interest and conceptual understanding.

Conversely, finding students' extrinsic attitudes towards science, like 'science offers better job opportunities for the future' failing to influence in the same way. Certainly, the House of Commons (2002) report suggests that career aspirations are rather influential. Additionally, Baker (1998) found that students having a negative attitude towards science may have more to do with the student not finding themselves suiting the image of science or lacking cognition in science.

There has been research (Koballa & Glynn, 2007) suggesting that students' affective factors consist of two theoretical areas: their attitudes towards science and their interest in science topics, where interest here means a direct causal factor influencing students' learning behaviour. Indeed, as Mamlok-Naaman, Ben-Zvi, Hofstein, Menis, and Erduran (2005) showed, pure acquisition of knowledge has little effect on students' attitudes, especially within western society where student voice is prominent. Mamlock-Naaman et al., (2005) explain that "if students are not interested in science, they tend not to make an effort to learn and understand the meaning of concepts that are being taught to them" (p.488). This could mean that students who are interested in science and understand the scientific concepts may hold more positive attitudes towards science and science studies than those who struggle with learning in science. Also, what can be seen here is the effect that the affective and cognitive domain can have on the behavioural domain, students not interested and lacking knowledge are more likely to disconnect with studies and become unmotivated to science.

According to Lunetta, Hofstein, and Clough, (2007) a valid and reliable measure of assessing students' perceptions of a learning environment using practical work was a "Science Laboratory Environment Inventory". The Science Laboratory Environment Inventory (SLEI) examines the learning environment in laboratories by questioning students' perspectives of their realities environment and desired one using a Likert type scale. The main usage of the Science Laboratory Environment Inventory was to examine "Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environments in the laboratory class" (Fraser, 2007, p.110).

Alternative measures of attitudes towards science have more recently been researched and commented on. A recent study by Kind, Jones, and Barmby (2007) commented on five main methods which have been reviewed by Osborne, Simon, and Collins, (2003) and Gardner (1975), these include: preference ranking, attitude scales, interest inventories, subject enrolment, qualitative methods. Despite the variety of measures and the difficulty in measuring attitudes effectively, Kind, Jones, and Barmby (2007) used attitude scales to measure their subjects' attitudes towards science because of the increased reliability and simplicity of usage. They go on to discuss how any attitude measure needs to be "statistically *internally consistent* and *unidimensional*" (p.875, italics in original) due to the fact that many studies (Bennett, 2005; Gardner, 1975; Osborne et al., 2003) comment on them being of a poor psychometric quality.

Whilst the literature stresses the need to clarify explicitly the meanings of the attitude constructs, it is possible to effectively measure students' attitudes towards science. Indeed, work by Reid (2006), discusses how effective attitudinal measures can be used in methodologies which can give a better, more useful, detailed analysis. The key areas that are applicable to this study and reported by Reid (2006) include:

The measurement of attitudes is, therefore, extremely important and there is a need for valid approaches which are accurate and offer rich insights…. Absolute measures of attitudes are impossible. Only comparisons can be made….There are numerous paper-and-pencil approaches: based on Likert, as well as rating questions and situational set questions, interviews can offer useful insights.

The key messages from this is that whatever method is to be adopted for the collection of data for this study, it needs to be a valid approach which not only uses pencil and paper questionnaires but also interviews to better enrich the quality of the data collected.

Indeed, Reid (2006) stresses that the approach of an attitude scale is best avoided because whilst a simple number is gained, the specific detail and precision is lost because of the reliance on purely categorical data: a slight concern when an attitude - that which is being researched is far from an absolute or explicit concept.

However, whilst the instrument would strive from a more descriptive and empirically driven approach, such as the Views on Science-Technology-Society (VOSTS) approach by Aikenhead and Ryan (1989), an attitude can be described and analysed in terms of the three component parts. Therefore, with understanding an attitude as being the result of the tripartite model – involving affective, cognitive and behavioural domains. Reid (2006) defines how these three domains can be defined in terms of application to research:

(1) Knowledge about the object, the beliefs, ideas component (Cognitive);

(2) A feeling about the object, like or dislike component (Affective); and

(3) A tendency-towards-action, the objective component (Behavioural).

Using the three definitions for affective, cognitive and behavioural a students' attitude can be better explained and analysed. For example, a student who is giving their attitude towards studying physics would need to know (Reid, 2006): some knowledge of what physics is and involves; what their feelings are towards physics – which could be determined from what they *know* about physics; and whether they feel a tendency, or a committed to studying physics beyond compulsion. However, whilst this appears to suggest that a student would need all three components to involve a positive attribute in order to form a positive attitude, the balance between the three can vary (Reid, 2006) and Wilson, Lindsey and Schooler (2000) do suggest that these three components can, and do, exist with some inconsistencies. So this suggest that for students claiming they enjoy practical work (affective domain), they can say or indeed show that they struggle to understand, and often avoid to see, the required learning outcomes – which follows the work by Abrahams and Millar (2008) (cognitive domain) and whilst these two domains are inconsistent, they may still not continue with science (behavioural domain).

Reid (2006) claims that the behavioural domain in science education is often dubbed in terms of science uptake post compulsion. Although if within the behavioural domain of a students' attitude to practical work, it is seen as a motivating factor for doing science, it might be expected that the numbers continuing with science post compulsion because of practical work. Students may show that positive attributes within the affective domain, they need not hold positive attributes within either of the other two domains. Indeed, as Wilson *et al*., (2000) discuss, there may be conflict between the three domains but Rosenberg (1960) argues that at this time people are more inclined to change their attitude to ensure there is consistency between the three domains. When students claim they enjoy practical work it may be therefore that the strength of the affective domain overrides the other two domains and whilst causing a conflict here, for the younger students this may be the main objective, to just enjoy doing practical work in science as opposed to the cognitive domain or retention post compulsion (behavioural domain). It seems understandable that for students who provide descriptive accounts of practical work that were memorable in some way other than be able to recall what they learnt from it (Abrahams & Millar, 2008) would be referring to the affective domain when giving an answer to why they like or do not like practical work. Indeed, for most students at the start of secondary school science their attitudes within science at least are very positive and they then start to decline by the end of secondary around aged 16 (Woolnough, 1994).

One conclusion that can be made is that whilst there have been comments by students about their claims of enjoyment in and for practical work as part of a wider study into students attitudes (Toplis, 2012), there needs to be more in depth research into the explanations for why students feel the way they do.

Furthermore, as attitudes can only be inferred (Reid, 2006), any means of using multiple approaches to the method of data collection can therefore benefit and enrich the results.

Indeed, questionnaire can gauge the cognitive and affective domains of students but it may well be worthwhile to see the behavioural domain by observation.

CHAPTER THREE

METHODOLOGY

3.1: Overview

This chapter is devoted to the following; design of the study, population and sampling procedure. It continues with the instrumentation, reliability and validity, pilot test, data collection, and data analysis.

3.2: Research design

The study was quasi experimental research design with mixed quantitative and qualitative data. This research design made use of practical work in teaching physics as an intervention, and the use of pre-and post-treatment test as well as students' questionnaire items. The design helped the researcher to use questionnaire to objectively measure how the students perceive the effectiveness of practical work during lessons.

The results of the post intervention test aided the researcher to test hypotheses on the performances of both the experimental group and the control group. The experimental students' responses to the questionnaire items were used to discuss and analyze the perceptions of the effectiveness of practical work in the teaching and learning of physics in schools.

3.3: Population and Sampling Procedure

Sampling refers to the process of selecting a portion of the population to represent the entire population (Fraenkel & Wallen, 2000; Muijs, 2004; Alhassan, 2006). In this study, seventy-two second year science students were selected as a sample group from a total form two science student population of one hundred and forty seven, based on their performance in their form one third term exams (which was used as a pre intervention test). Purposive sampling technique with the help of the pre-intervention test was used to sample a total of thirty-six students as experimental group and another thirty-six group as a control group.

The purpose was to get a sample size of thirty-six students as those within the lower scores limit in the pre-intervention test as the experimental group, and the remaining thirty-six with the higher scores limit as the control group. The experimental group consists of students whose scores in the pre-test fell below 50%. The modal age of the participants was 16years.

3.4: Treatment

Two instructional techniques were used to teach students over a period of one term. Students were taught one topic in each of the months in the term. Practical work was the main instructional technique used in teaching the topics in the experimental group. The students were actively involved in setting up the equipment and apparatus used in the laboratory, during the practical activities. This was to help students in acquiring science process skills. After each experiment, there was intensive class interaction and discussion led by the class teacher. Experimental procedure, data collection, manipulation and analysis procedure were always reviewed in the class before the students were required to complete writing the laboratory reports. The instruction in the control group did not stress much on practical work. Most content in this group was theoretically covered. Teacher demonstrations were the standard way of showing the learners the practical aspects of the topics.

3.5: Instrumentation

The main instruments used include a set of pre and post-treatment test items as well as students' questionnaire. The scores of the pre intervention and post intervention test items were used in the analysis to answer the research questions. End of month test was administered to the respondents throughout the term. Specific tests evaluating the work done in each topic was given at the end of each month. An end of term exams was organised for both group. These were graded and eventually compiled at the end of the term. They formed the post-test scores. In addition, all the students were given End of Term Attitude Questionnaire. The student's questionnaire items were chosen to gather the data and further buttress findings on the effectiveness of using experiments as instructional strategy in physics education.

The general benefits of a questionnaire which include consistency of presentation of questions to the respondents, the assurance of anonymity for the respondents and the less time it takes to administer (Fraenkel & Wallen, 2000; Muijs, 2004) was appropriate for this study which was time bound. A questionnaire was also found to be appropriate for the study because the study employed a discussion of experimental student's perception on the effectiveness of using experiments in physics instruction.

Questionnaire is probably the most common data collection instrument used in educational research which is more familiar to respondents (Muijs, 2004). However, the disadvantages are that they often have low response rates and cannot probe deeply into respondents' opinions and feelings (Fraenkel & Wallen, 2000; Muijs, 2004; Alhassan, 2006), but this was not the case with this study because the sample size was well manageable.

Close-ended items made respondents to choose between answers of the researcher while open-ended items allow respondents to formulate their own answers. The researcher used both open and closed ended items in the questionnaire because respondents are more inclined to answer close-ended items and open-ended items provides a greater depth of responses since there was no standardized answers across responses (Oppenheim, 2000).

3.6: Scoring the questionnaire items

A Likert scale with five options (Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD)) was used to score the questionnaire items. The items on the questionnaire were positively and negatively worded in order to minimize participant satisfying responses. Positively worded items (e.g. "Students are more enthusiastic about the subjects for whom teachers use experimental approach as instructional method") were scored as follows:

Response Intensity	Symbol	Score
Strongly Agree	SA	5
Agree	A	4
Neutral	N	3
Disagree	D	2
Strongly Disagree	SD	1

Negatively worded items (e.g. "Using experiments as instructional method hinder students' ability with learning tasks") were scored as follows:

Response Intensity	Symbol	Score
Strongly Agree	SA	1
Agree	A	2
Neutral	N	3
Disagree	D	4
Strongly Disagree	SD	5

Likert scale was used to score the questionnaire items because it looks interesting to respondents and people often enjoy completing a scale of this type (Muijs, 2004). Again, Likert scale is easier to construct, interpret and also provide the opportunity to compute frequencies and percentages as well as statistics such as the mean and standard deviation of scores. This in turn, allows for a more sophisticated statistical analysis such as Analysis of Variance (ANOVA), t-test, chi square and regression analysis (Fraenkel & Wallen, 2000; Muijs, 2004). Additionally, Likert scales are often found to provide data with relatively high reliability (Oppenheim, 2000; Fraenkel & Wallen, 2000).

3.7: Validity and Reliability of instrument

The quality of a research instrument or a scientific measurement is determined by both its validity and reliability (Aikenhead & Ryan, 1992). Validity seeks to determine whether the instrument actually measures what is intended to be measured and reliability, on the other hand, it refers to the consistency of data when multiple measurements are gathered (Gott, Duggan & Roberts, 2003).

The instruments for the study were designed for exploring how the use of practical work as an instructional method enhances students' understanding in physics at the SHS level.

The expertise of Science Education Lecturers from the Department of Science Education was drawn to validate the instruments for content and face validity of the instruments.

The West African Examinations Council syllabus and the Ghana Education Service syllabus for Physics for Senior High Schools were used as a guide to ensure adequate reliability and validity of the research instruments. The required content materials for the selected topics were extracted from the Ghana Association of Science Teacher (GAST) Physics and other relevant advanced physics textbooks. The extracted content materials were used to prepare Student-and teacher-centred Instructional Strategy Package. The research instruments consisted of lesson notes, students' test items and questionnaires, experiments on selected topics and other relevant instructional materials.

The validation of the content material as well as the Student-and-teacher-centred Instructional Strategy Package were carried out through the assistance of some experts in physics Education in the Department of Science Education, Winneba. The validators were asked to determine the appropriateness of the content material and to find out whether the instructional package can be used to achieve the purpose for which it is designed for. The recommendations of the validators were used to revise the content material and the instructional package. These were followed by a trial test of the instructional package through a pilot test.

Reliability is about the consistency in a research result. If the survey is given again, will it yield the same or similar results? Reliability of the data can be assessed if the items are examined to show internal consistency.

3.8: Pilot Test

A pilot test of the instrument was carried out at the school with twenty (20) students from form two during the second term in the 2012/2013 academic year. This pilot test was to establish the reliability of the questionnaire, and also to identify defective items in order to avoid any ambiguities that might occur and get an idea of the expected response before administering it to the actual participants of the study. The pilot test was to enable the researcher to detect weakness in the research instruments, and correct them. The pilot test was tested a term prior to the actual data collection to ensure that all weaknesses observed in the instructional package during the pilot study were addressed in order to revise the package to improve its reliability. The pre and post-test items internal consistency was determined by the use of test retest method of reliability co-efficiency. A high reliability value of (0.79) and (0.84) for the pre and post-test respectively was obtained with the use of cronbach's alpha computation relation,

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K}\sigma_{Y_i}^2}{\sigma_X^2}\right)$$

where K is the number of components (*K-items* or *testlets*), σ_X^2 the variance of the observed total test scores, and $\sigma_{Y_i}^2$ the variance of component *i* for the current sample of persons. Alternatively, the Cronbach's α can also be defined as

$$\alpha = \frac{K\bar{c}}{(\bar{v} + (K-1)\bar{c})}$$

where K is as above, $\bar{v}$ the average variance, and $\bar{c}$ the average of all covariance between the components across the current sample of persons.

3.9: Data Analysis

This study employed both qualitative and quantitative methods of data analysis. The pre-intervention and Post intervention test mean score of both experimental and control groups were analyzed quantitatively and qualitatively to determine the impact of practical work on students' understanding on the selected topics in physics.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: Overview

In this chapter, the findings from the investigation into the effect of practical work on students' understanding in physics are presented and discussed in relation to the three research questions. The research questions are discussed with the use of quantitative z-test and t-test statistical tool and qualitative descriptive analysis of the pre-and post-test mean scores as well as the responses of questionnaire for the students. The findings of the study are discussed based on the research questions of the study.

4.2: Research question one

What is the effect of practical work on students' performance in physics?

The Pre-Test scores for both the experimental and the control groups were obtained from the end of form one examinations. The experimental and the control groups mean performances in the pre-test were determined and compared.

The total scores on the end of month tests and the end of term exams were compiled and expressed as a percentage, for every respondent in each of the experimental and control groups. The end of month tests and the end of term performances constituted the Post-Test scores. The mean performance and the standard deviations for each group were determined. The results are indicated in Table 1.

Table 1: Group Performances in the pre and post tests

Group	Type of test	No. of Respondent (N)	Mean performance (%)	Standard Deviation	Z-Test	P-Value
Experimental	Pre-test	36	34.75	9.12		
Control	Pre-test	36	65.67	10.20	-13.36	0
Experimental	Post-test	36	61.44	10.24		
Control	Post-test	36	59.42	9.69	0.86	0.39

The experimental and the control groups had mean performances of 34.75% and 65.67% respectively on the Pre-Test. The result clearly shows that there is significant difference in the performance between the two groups at the beginning of the study. The result indicates that the two groups were not comparable on their initial understanding of the taught concepts in the study of physics in the first year. Therefore, the z-test analysis of the pre-test scores for both groups shows the existence of a significance difference between their mean scores as seen from Table 1 ($z = -13.36$; $p < 0.05$).

Table 1 shows an increase in mean performance from 34.75% in the pre-test to 61.44% in the post test by the experimental group as compared to a decrease in mean performance from 65.67% in the pre-test to 59.42% in the post-test by the control group. This indicates that the experimental instructional technique was having a positive effect on the respondents' direct understanding on the items in the post-test. The respondents were developing a focused view-point about the task requirements after instruction. Since the experimental and control groups were more than thirty, the *z*-test was used to determine significance of difference of the means from the post-test.

Therefore, from Table 1, z-test analysis of the mean score on the post-test shows no significant difference (z= 0.86 and p>0.05) in performance between the two groups. The experimental group demonstrated a better conceptual understanding of the taught physics concepts with the use of practical work, which was reflected in their post-test mean score value after the intervention.

4.2.1: Testing null hypotheses one

There is no significant difference in performance between the students in the experimental group taught using practical work and the control group students.

A two-tailed z-test was employed for the verification of the post test mean scores of the experimental and the control groups. It was observed that the calculated z -value (z = 0.86; p>0.05), was not significant at a probability level of 0.05 as shown in Table 1.

It is therefore suggested statistically; that the null hypothesis is accepted at 95% confident level because the use of practical work had been able to raise the performance of the experimental group.

The results from the current research resonate well with Amadalo, Ocholla and Memba (2012) which determined that involving students in meaningful practical work contributes to improved performance. Uwaifo (2012) found a statistically significant relationship between theory and practical scores on all science subjects. Wasanga (2009) also found a similar correlation between practical work and understanding of science subjects which leads to improved performance in achievement tests. Amunga, Musasia and Musera, (2011) have demonstrated that practical work makes the students take learning science seriously. The determination to unravel the requirements of the objectives of the practical task leads the learners to take charge of the learning situation and to develop an insight in the requirements of the tasks involved in the practical work. They established this to be primarily true when the practical work was enjoyable and meaningful to the students.

In summary, this hypothesis rightly answers the research question one posed in this study that "Is there any difference in students' performance in physics between the experimental group and the control group?"

4.3: Research question two

What is the effect of practical work on students' attitude towards the study of physics?

The End of term student's questionnaire was used to investigate the development of the two groups' attitudes towards identified features concerned with learning physics. The four attitudinal concerns that were investigated were:

A: Ability to understand the topics taught

B: Ability to arouse and maintain interest

C: Ability to communicate and interpret results

D: Ability to relate taught concepts to everyday life activities

A Likert scale with five options (Strongly Agree=5, Agree=4, Neutral=3, Disagree, and Strongly Disagree=1) was used to score the questionnaire items. On the Likert scale, scores of 4 and 5 were considered High scores whereas scores of 1 and 2 were designated Low scores. A score of 3 indicated an average score, interpreted as being neutral about the concerned attitudinal attribute. Table 3 shows the frequency (N) and percentages (%) of respondents from each of the experimental and the control groups on each attitudinal concern.

Table 2: Groups Response on Investigated attitudes

Item investigated	Experimental Group Attitude score			Control Group Attitude score		
	High (N,%)	Neutral (N,%)	Low (N,%)	High (N,%)	Neutral (N,%)	Low (N,%)
A	33 (91.67)	2 (5.56)	1 (2.77)	15 (41.67)	13 (36.11)	8 (22.22)
B	28 (77.78)	5 (13.89)	3 (8.33)	6 (16.67)	11 (30.56)	19 (52.78)
C	30 (83.33)	4 (11.11)	2 (5.56)	12 (33.33)	16 (44.45)	8 (22.22)
D	21 (58.33)	10 (27.78)	5 (13.89)	12 (33.33)	10 (27.78)	14 (38.89)

Table 2 indicates that the experimental group had more respondents (91.67%) who understood the topics after instruction compared to the control group (41.67%). There were fewer respondents in the experimental group (5.56%) who were undecided about whether they understood the topics compared to the control group (36.11%). After going through the course, 77.78 % of the experimental group respondents reported having developed a better interest in physics compared to only 16.67% of the control group. Only 13.89% were not sure whether the intervention helped in raising their interest in the experimental group as compared to 30.56% in the control group. About 52.78% in the control group claim the method of instruction did not help in raising their interest in the subject as compared to 8.33% in the experimental group.

The issue of student interaction during instruction also favoured the experimental group. The experimental group had 83.33% of the respondents indicating that there was a lot of student-student interaction compared to only 33.33% of the control group who felt there was adequate interaction amongst the respondents. This interaction included discussions on the best ways of effecting equipment and apparatus connections, joint working out of solutions to problems provided at the end of the practical task, and determination of applications of theory work outside the classroom. Application of the topics outside the classroom and into everyday life activities indicated that 58.33% of the experimental group felt that they were able to do this satisfactorily compared to only 33.33% of those in the control group.

4.3.1: Testing null hypotheses two

There is no significant difference in attitude change between the experimental group and the control group

A t-test analysis conducted on the high scores of both groups at a confidence level of 5% (α = 0.05) showed a calculated t-value (t= 6.09, $P<0.05$) which is greater than the tabulated value of 3.18. Thus the attitude of the experimental group was statistically different from that of the control group. Hence we reject the null hypothesis that "There is no significant difference in attitude change between the experimental group and the control group"

This lends credibility to the observation that the experimental group had developed better attitudes as a result of practical based instruction in physics. The findings of this study concerning respondent formed attitudes agree with the observations of Toplis and Allen (2012) who suggested that practical work has been used as an integral effort of ensuring that learners develop an in-depth understanding of content during the formative years of secondary school science learning. Talisayon (2006) also found out that learners developed improved attitudes towards science as a result of practical courses. Kim and Chin (2011) have reported that practical work was a significant tool for developing students‟ scientific knowledge and habits of mind which concurs with the finding that practical work contributed to increased ability to understand the content in this study.

4.4: Research question three

What is the effect of practical work on students' acquisition of science process skills?

In the first term in form two, the two groups were taken through topics in Heat energy, sources of electricity and magnetism. The experimental group instructional technique emphasized practical work when teaching the topics. Table 4 shows the topics treated and the experiments conducted during the term.

Table 3: Available Topics and Experiments for the Term

Topics	Sub-Topics	Practicals Details
	Heat as a form of Energy	Produce heat by rubbing.
Heat Energy	Lower & upper fixed point	Calibrating the lower & upper fixed point of an uncalibrated liquid in glass thermometer.
	Linear Expansion	Measuring the linear expansivity of a metal
	Primary Cells	Investigating Electrolysis
Sources of Electricity	Secondary Cells	Making a Lead-acid cell
	Other types of cell	Preparing fuel cells
Magnetism	Magnetising a magnetic substance	Magnetising a magnetic material by a single touch method.
	Magnetic Fields	Investigating magnetic field lines around a bar magnet.
Magnetism	The Earth as magnet	Investigating the combined effect of a magnet and the earth field.

The experimental group participated in all the experiments. The control group managed to do three experiments in total namely, producing heat by rubbing, preparing fuel cells and investigating magnetic field lines around a bar magnet.

Table 4: Acquisition of Basic Science Process Skills after the Term

	Science Process Skills					
	Measuring		Observing		Recording	
Group	No.	%	No.	%	No.	%
Experimental	32	88.89	34	94.44	35	97.22
Control	20	55.56	26	72.22	24	66.67

Table 4 shows the percentage of the respondents who were certain that they had gained the requisite science process skills investigated as a result of performing practical work during the term. The Experimental group reported having acquired more experience in all the indicated process skills compared to the control group. Both the experimental and control groups reported that they really liked the idea of producing heat by rubbing, preparing fuel cells and investigating magnetic field lines around a bar magnet. The control group showed enthusiasm with the experiments, though they wished that they would have done more experiments during lessons. However, the experimental group performed the rest of the experiments meant for the term. The experimental group reported these additional experiments helped in making the taught concepts more clear and real. The experimental group were able to determine the lower and upper fixed points of some liquid in glass thermometers as well as calculating the linear expansivity of a metal. They reported that the experiments in the electricity helped them to know how to minimise the defects of some cells and accumulators. The experimental group were enthused to have produced their own magnet by the single touch method.

The findings from the current research are in tandem with several research findings on the acquisition of practical experimental skills. Tifi, Natale and Lombardi (2006) suggest that investigations allow learners to reach their own conclusions. When done in groups the gained process skills allow development of social skills of collaboration, sharing, debating and extending ideas in the group. Prokop, Prokop and Tunnicliffe, (2007) said observation and data recording can have an important impact on developing understanding. Since understanding the scientific phenomena also reduces the learning of plain facts and makes instruction more interesting. Chabalengula, Mumba and Mbewe (2012) have demonstrated the usefulness of mastery of science process skills among elementary school science teachers. The performance of the elementary teachers was certified to have become more meaningful for those who had practically gained them.

4.5: Research question four

What is the perception of the experimental group about the use of practical work in the study of physics?

Table 5: Respondents perceptions about the effectiveness of practical work as an instructional method

Items.	SD n (%)	D n(%)	N n (%)	A n (%)	SA n(%)
11. I was more enthusiastic and motivated during the use of practical work in the teaching and learning of the taught concepts.	4(5.56)	6(8.33)	14(19.44)	23(31.94)	25(34.72)
12. The use of practical work as instructional techniques is an effective strategy for students of all abilities.	2(2.78)	8(11.11)	9(12.50)	11(15.28)	42(58.33)
13. The use of practical work during instruction reduces my personal interaction with my colleagues.	36(50.00)	17(23.61)	12(16.67)	6(8.33)	1(1.39)
14. The use of practical work makes me feel like I am lost in a jumble of numbers and words.	51(70.83)	12(16.67)	6(8.33)	2(2.78)	1(1.39)

15. The use of practical work as instructional strategy would promote students understanding of concept and do away rote learning as well as memorization of facts.	0(0.00)	6(8.33)	12(16.67)	16(22.22)	38(52.78)
16. Practicals hinder students' ability with learning tasks (e.g., writing, analyzing data, or solving problems).	25(34.72)	36(50.00)	8(11.11)	1(1.39)	2(2.78)
17. The use of practical work as instruction is an effective means of helping students to understand theories laws and principles.	2(2.78)	2(2.78)	22(30.56)	35(48.60)	11(15.28)
18. Doing practical work make me feel more involved in the learning process.	0(0.00)	1(1.39)	10(13.89)	47(65.28)	14(19.44)
19. The use of practical work as an instructional method reduces forgetfulness and recitation of mnemonics as well as acronyms during examinations.	6(8.33)	9(12.50)	28(38.89)	18(25.00)	11(15.28)

20. The use of practical work for instruction would enable me to interact more with my colleague to promote group discussion.	1(1.39)	2(2.78)	10(13.89)	21(29.17)	38(52.78)
21. I think performing practical work in Physics is a waste of time.	49(68.06)	16(22.22)	5(6.94)	2(2.78)	0(0.00)
22. I always enjoy the lesson when our teacher makes us do practical work.	0(0.00)	2(2.78)	5(6.94)	16(22.22)	49(68.06)
23. I will be glad if we do practical work in all our lessons in physics.	0(0.00)	3(4.17)	8(11.11)	23(31.94)	38(52.78)

Table 5 indicates the perceptions of the respondents on the effectiveness of practical work as an instructional method in the teaching of physics in senior high schools. These responses are illustrated using graphs and charts as shown below.

Majority of the participants (66.66 %,) gave a positive (strongly agree and agree) response with item 11, which indicates that the: “integration of practical work in physics teaching will elicit student interest in Science concepts.” and this is graphically represented in Fig.2.

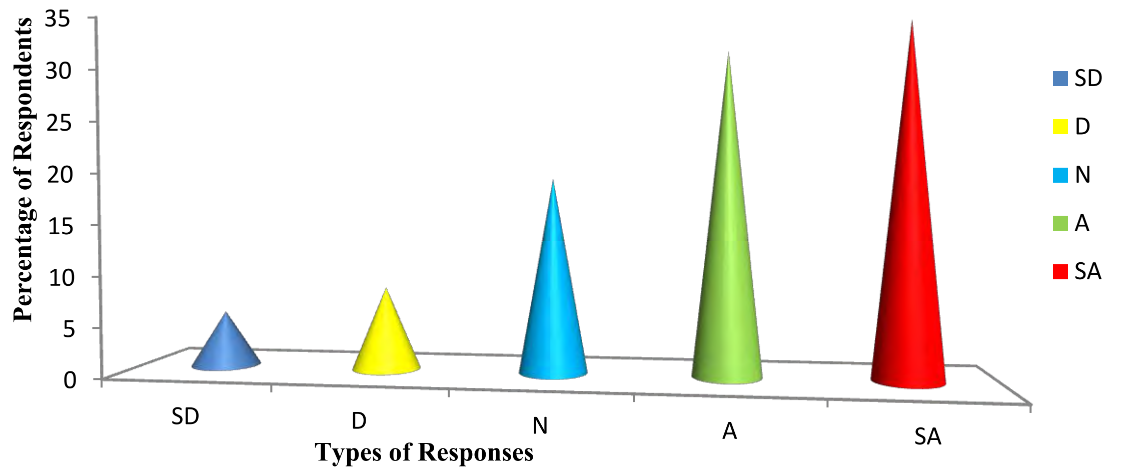

Fig2: Practical work elicit students' interest

About 73.61% of the participants gave positive (strongly agree and agree) response for item 12. This is an indication that most of the students believed that the use of practical work can help improve the technical abilities of individual students. Fig. 3 shows the responses given by the respondents.

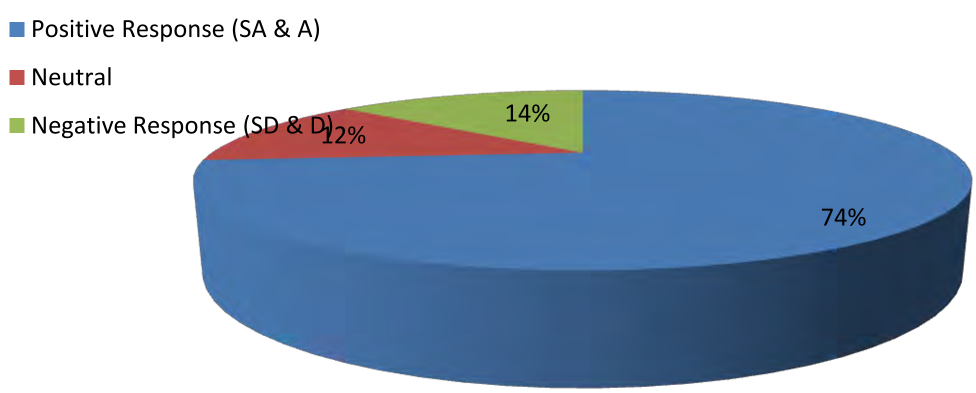

Fig3: Practical work helps students of all abilities

Fig.4 shows that 73.61 % of the participants disagreed and strongly disagreed with item 13, which states that “the use of practical work during instruction reduces my personal interaction with my colleagues”. This is an indication that the participants were able to collaborate and cooperate with one another during practical sessions. The response is represented graphically in fig.4.

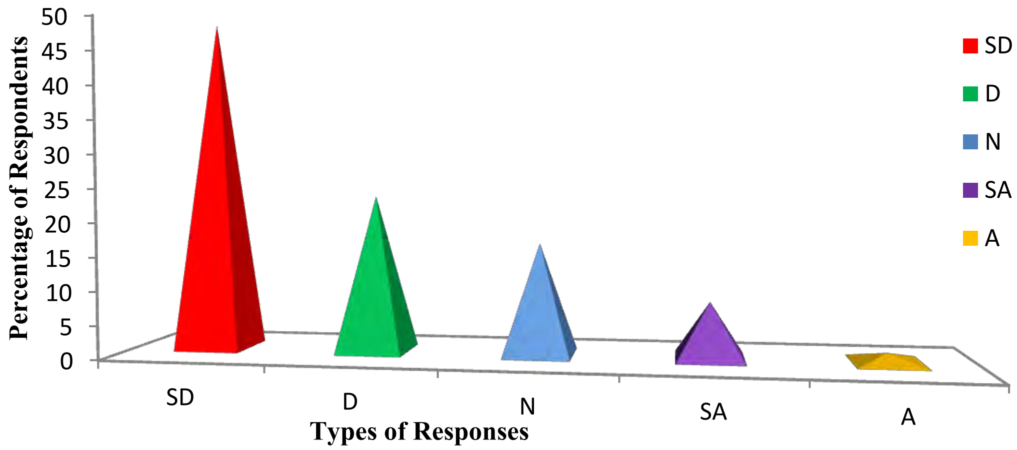

Fig4: Practical work hinders collaborative skills of Students

A total of 87.5 % of the respondents disagreed and strongly disagreed that the use of practicals makes them feel like they are lost in a jumble of numbers and words. This reveals that students are more likely to understand concepts when they are make real through practicals. This is shown in fig5.

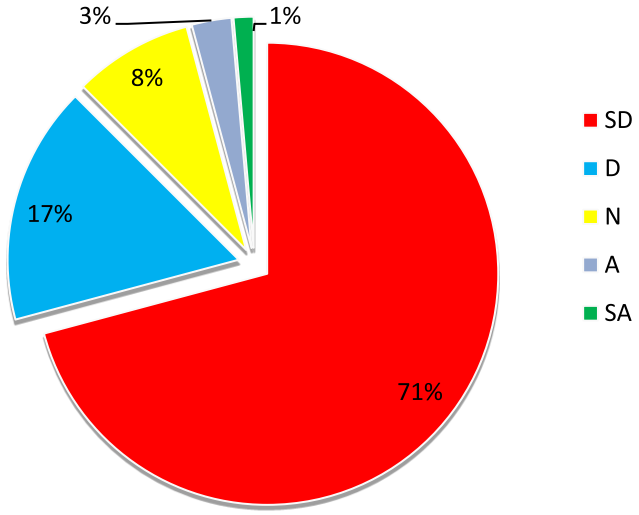

Fig5: Practical work makes concepts more real

For item 15, 75 % of the participants supported the idea that practical work as instructional method promote students' understanding of concepts and can do away with rote learning as well as memorization of facts. This shows that more than half of the respondent perceived that practical work helped them to understand the taught concepts rather than just committing the taught concept into memory by rote learning. This is represented in fig.6.

Item 16 was negatively coded, 84.72 % of the respondents were not in favour with the assertion that "practical work hinder students' ability with learning tasks (e.g., writing, analyzing data, or solving problems)". Fig 7 shows that more than half of the respondent perceived that practical work enhances students learning ability in physics through writing reports, and analyzing of result. Fig 8 also indicates that most of the participant agreed to the statement that the use of practical work as instruction is an effective means of helping students to understand theories, laws and principles. This suggests that performing practicals enhances students understanding of stated theories, laws and principles than telling them about the theories. For item 18, 84.72 % said doing practical work makes them feel involved in the learning process. This helps them to ask questions to clear any form of confusion that they have. This response is represented graphically in fig 9.

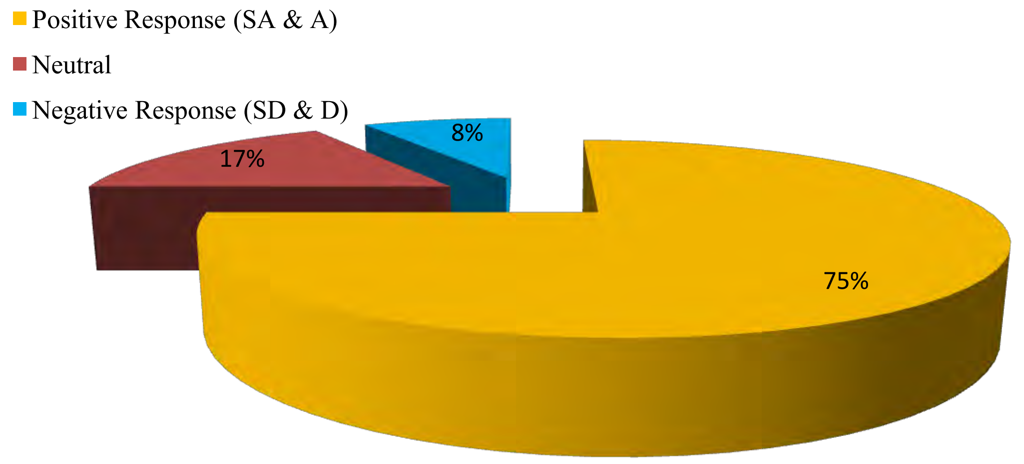

Fig6: Practical work can curb rote learning

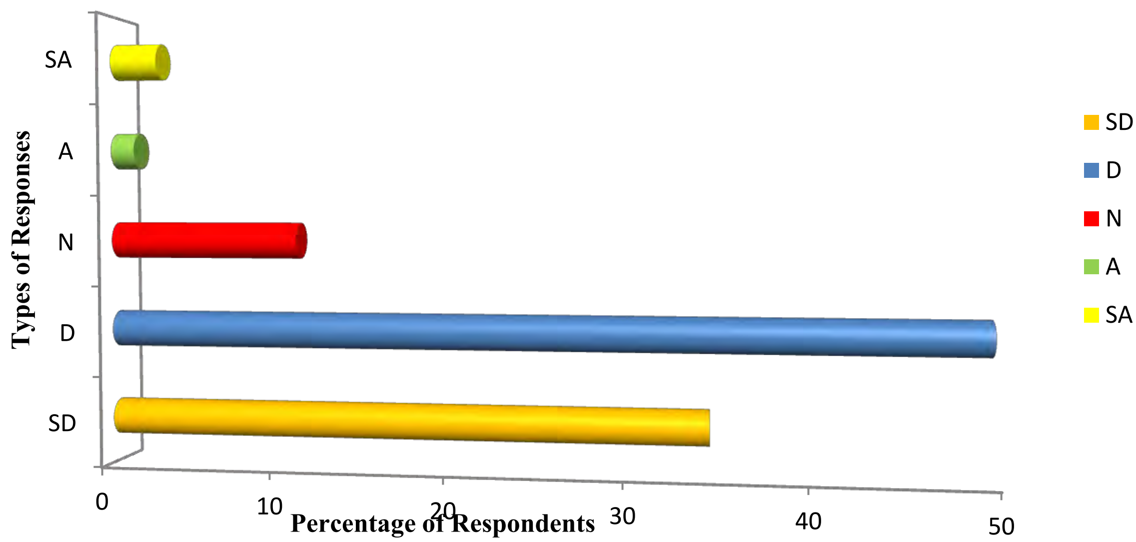

Fig7: Practical work hinder students' ability with learning task

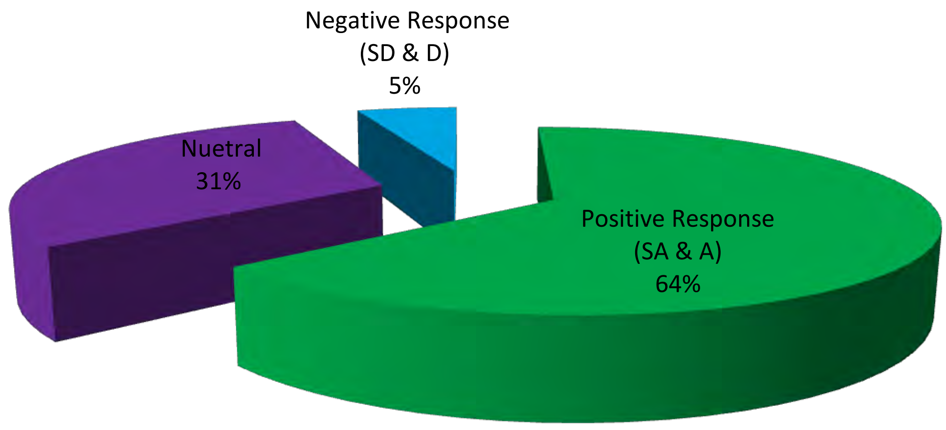

Fig8: Practical work explains theories, laws and principles better

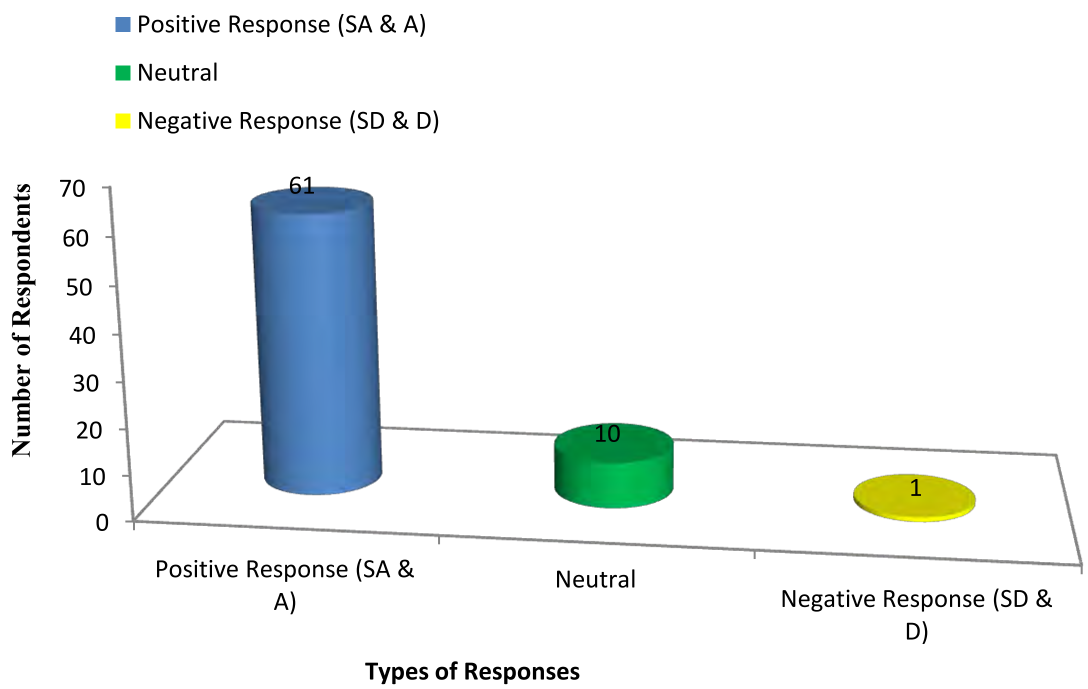

Fig 9: Practical work promotes students participation

Almost 41 % of the participants concurred with the notion that the use of practical work as an instructional method reduces forgetfulness and recitation of mnemonics as well as acronyms during examinations, as compared to 20.83 % of the participants who disagreed. This is shown in Figure 10. Also Figure 11 shows that more than half of the respondents strongly agreed that performing practicals promote group discussion, which is a nice platform for sharing ideas and developing cooperative skills. Over two thirds of respondents strongly opposed the view that performing practical work in Physics is a waste of time. This could be an indication that the use of practicals during the instructional process might have helped addressed some of the challenges they were facing in the topics being treated. This assertion is graphically represented in Figure 12. As indicated in Figure 13, 77.78 % of the respondents strongly agreed that they are always excited whenever they are to perform practical work during physics lessons. It was observed that 84.72% of the students wished that practical work is used as the means of instruction in physics class. This response is indicated in fig 14.

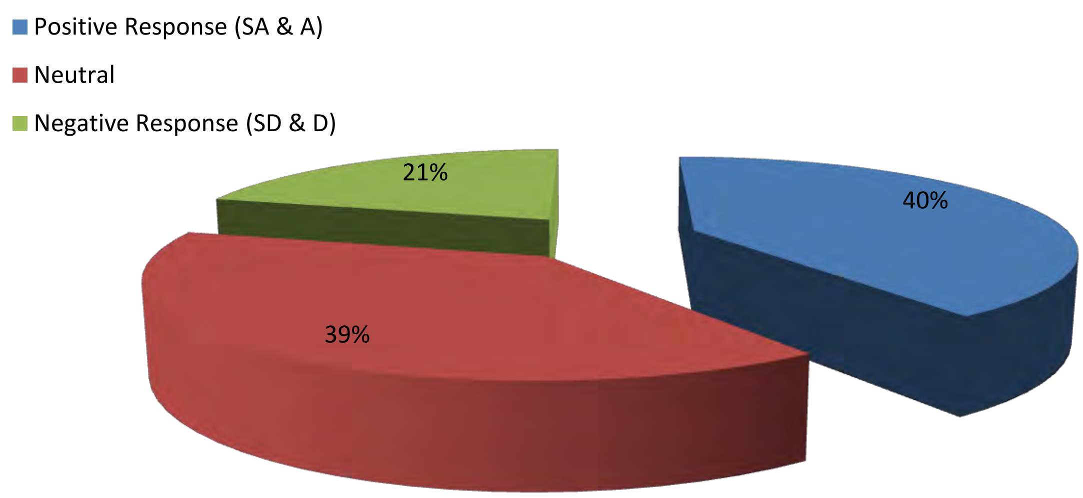

Fig 10: Practical work enhancess recall of facts

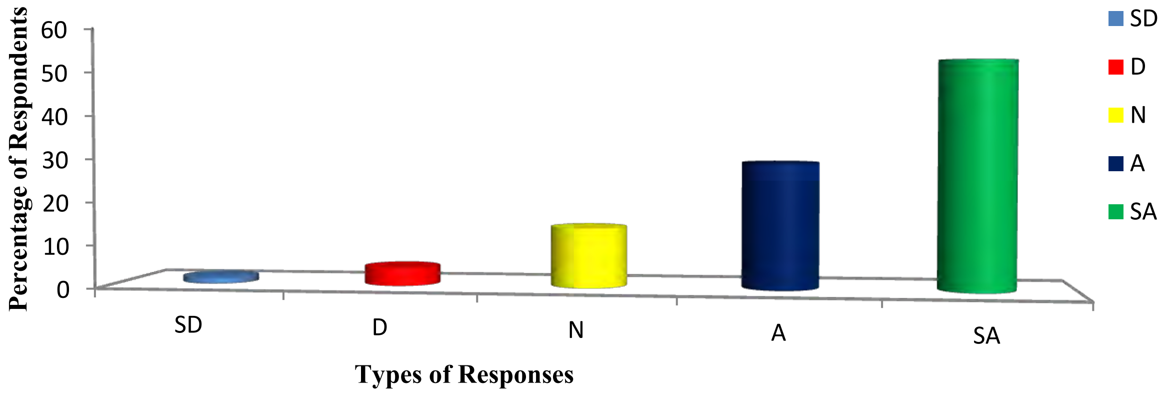

Fig 11: Practical work promotes group discussions

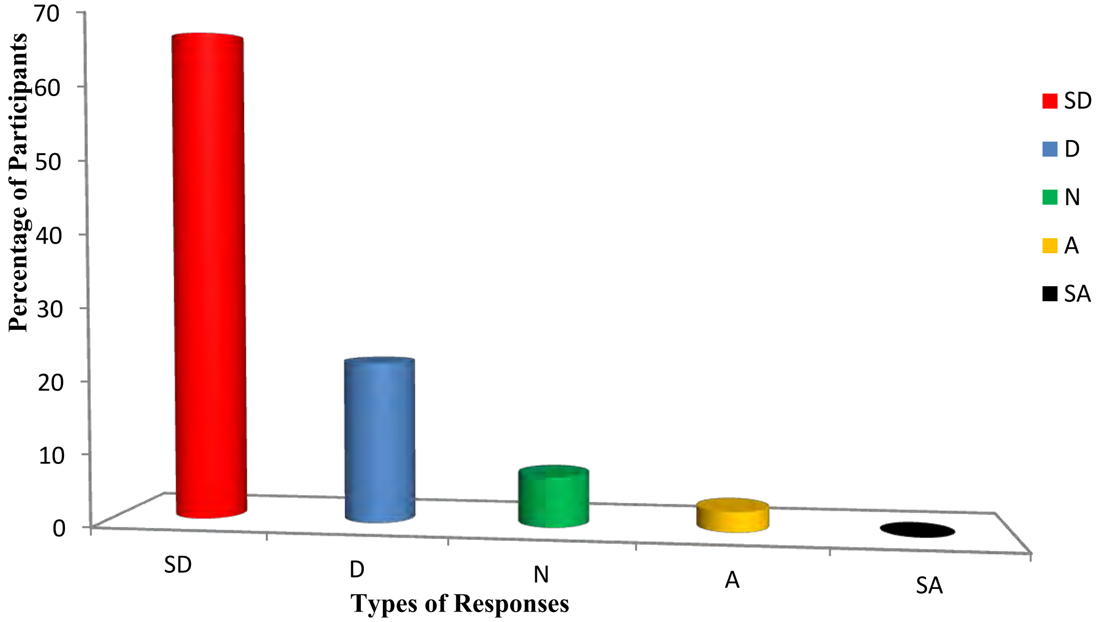

Fig 12: Practical work in Physics is a waste of time

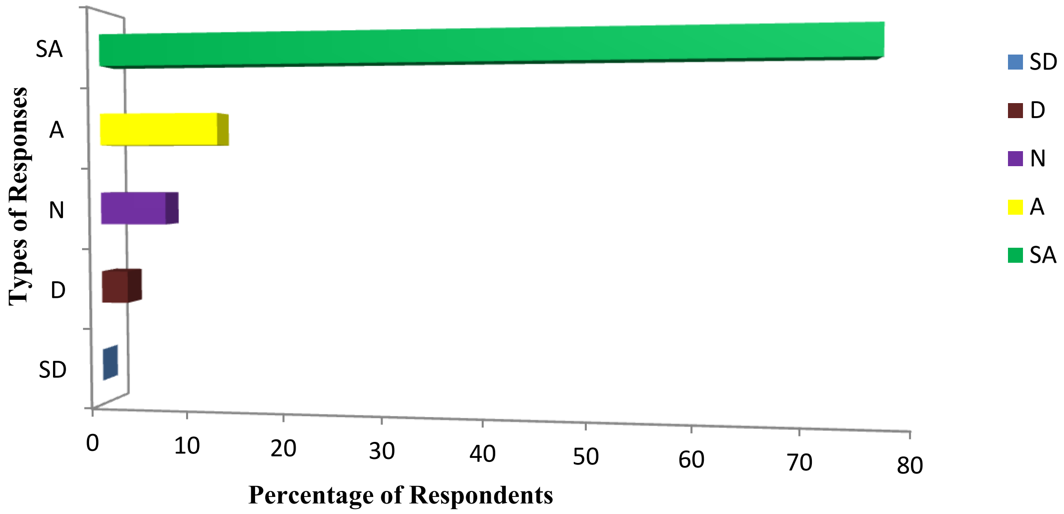

Fig13: I enjoy lessons when we do practical work

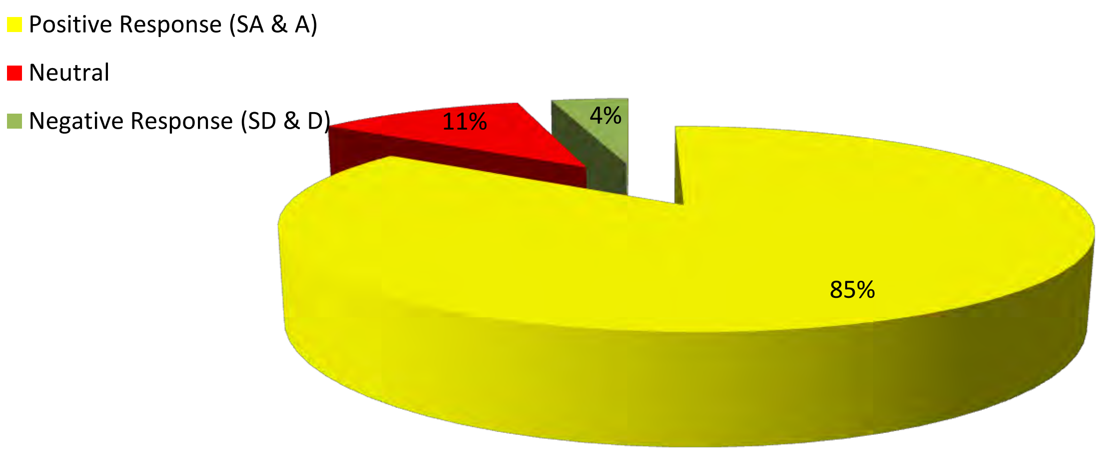

Fig 14: Practical work should be used as a means of instruction in Physics

The response from the questionnaire shows that most of the students believe that performing practicals during lesson in physics is an effective means of enhancing students understanding in physics. Some students suggest that learning in physics class should use this instructional approach because it makes the learning process interactive and real.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1: Overview

This section of the study discusses the summary of findings and significant ideas and conclusions of the study for the effect of practical work in physics teaching. It continues with recommendations from the findings of the research.

5.2: Summary of findings

5.2.1: Research question one

What is the effect of practical work on students' performance in physics?

Before the use of practical work as instructional strategy in the teaching of physics, the experimental group was the sample that failed to achieve above 50% and had a mean performance of 34.75% in the pre-intervention test. But after the use of the intervention, it was realised that the mean performance of the experimental group have increased to 61.44%. A statistical analysis on the mean performance on the post-test of the experimental and the control group showed equal performance among the two groups.

This shows that with the use of practical work, the experimental group of students' general performance had improved significantly from a mean performance of 34.75% to 61.44%, this indicates that practical work in teaching physics has a greater advantage of enhancing students understanding and retention of taught concepts.

5.2.2: Research question two

What is the effect of practical work on students' attitude towards the study of physics?

In research question two, four main attitudes of the groups were investigated. The responses from the questionnaire showed that the experimental group have developed more of the positive attitudes. The experimental group had more respondents (91.67%) who understood the topics after the use of practical work as means of instruction compared to the control group (41.67%). 77.78 % of the experimental group respondents reported having developed a better interest in physics compared to only 16.67% of the control group. The experimental group had 83.33% of the respondents indicating that there was a lot of student-student interaction compared to only 33.33% of the control group who felt there was adequate interaction amongst the respondents. Application of the topics outside the classroom and into everyday life activities indicated that 58.33% of the experimental group felt that they were able to do this satisfactorily compared to only 33.33% of those in the control group.

The responses indicate that engaging students in practical activities during instructional period in physics is a sure way of helping them develop positive attitudes towards physics.

5.2.3: Research question three

What is the effect of practical work on students' acquisition of science process skills?

It was investigated whether engaging students in practical work enable them to acquire science process skills such as observing, taking accurate measurement and recording them accordingly. The response from the investigation indicates that the experimental group reported having acquired more experience in all the indicated process skills compared to the control group. A qualitative test conducted on the response proved that the experimental group has mastered the investigated science process skills as a result of regular practice during instructional periods as compared to the control group who had few practical sessions during their instructional process.

5.2.4: Research question four

What is the perception of the experimental group about the use of practical work in the study of physics?

The findings from the responses to the questionnaires items (11-23) in research question five suggest that most of the students support the view that the integration of practical work during instructional period is pedagogically useful in:

1. Eliciting students' interest in the learning of physics.
2. Providing the appropriate learning environment for students' of all learning abilities.
3. Promoting and developing students' collaborative skills.
4. Making taught concepts more real.
5. Helping students to do away with rote learning.
6. Promotes students participation in the learning process.
7. Engaging students in group discussions.
8. Helping students to expand and applying what has been taught in class so as to give them courage to exercise control over their environment.

5.3: Summary of significant ideas from the Findings

Below are the summary of significant ideas obtained from the major findings during the discussion of the research questions and the hypothesis of the study:

1. There was an equal performance between the experimental group and the control group.

2. There was a statistical significant difference in attitudinal change between the experimental group and the control group after the use of the intervention.

5.4: Conclusion

The study was to determine the effect of practical work in promoting students understanding in physics. The specific conclusions from the objectives findings are:

1. Engaging the experimental group in meaningful practical work contributes to improved performance in the topics from which the practicals were derived. The use of practical work as an instructional strategy made the experimental group develop interest on the topics under study. As this was evident from the performance of the experimental group after the use of the intervention. Discussing the results obtained from the practical session and guiding the group to draw their own conclusions allowed the students to develop better understanding of the topics treated. The understanding of the topics was founded on a personal experience rather than on a theoretical imposition.
2. The use of practical work during instructional periods resulted in a major change in attitude towards physics by the experimental group as compared to the control group. The experimental group recorded positive responses in all the investigated attitudes which is an indication that the use of the practical work has impacted positively in their attitudes toward physics. Most of the students in the experimental group agreed that they could apply the topics learnt in their daily life activities as compared to a hand full of students in the control group.

3. The continuous exposure of practical work to the experimental group enabled them to acquire science process skills in critically observing developments and changes during practical sessions, accurately measuring quantities and recording observed changes and data. As most of the experimental group reported having acquired more experience in all the indicated process skills compared to the control group. All these qualities are important for a successful career in science.
4. Meaningful practical work is an effective way of explaining concepts to students. Practical work has the potential of promoting and maintaining students' interest in the learning of physics since it makes the learning process more real and easy to comprehend by learners.

5.5: Recommendations

The findings and conclusions of this study are used to support the following recommendations.

It would be necessary for physics teachers to adopt the use of practical work as a technique in teaching so as to solve the problem of many students under performing in physics at the secondary school level. Since the use of practical work in teaching have the ability to raise and maintain students' interest in the studying of physics and also developing their science process skills.

The Ghana Education Service must entreat its circuit supervisors to ensure that physics teachers engage students in practical sessions. Anecdotal evidence shows that on the average most teachers would like to engage students in just the theory aspect of the subject so as to complete the syllabus in no time, as most of the teachers believe that the practical sessions is time demanding. In view of this, it is recommended that the study should be replicated in other regions of Ghana using other methodology to substantiate the findings from this dissertation.

REFERENCES

Abrahams, I. (2009). Does practical work really motivate? A study of the affective value of practical work in secondary school science. *International Journal of Science Education, 31* (17), 2335-2353.

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

Abrams, E. (1998). Talking and doing science: Important elements in a teaching for understanding Approach. In J. J. Mintzes, J. H. Wandersee & J. D. Novak (Eds), *Teaching science for understanding: A human constructivist view.* (pp. 308-322). San Diego, CA: Academic Press.

Adey, P., Hewitt, G., Hewitt, J. & Landau, N. (2004). *The Professional Development of Teachers: Practice and Theory*. Dordrecht: Kluwer.

Aikenhead, G. S., & Ryan, A. G. (1989). *The development of a multiple-choice instrument for monitoring views on science-technology-society topics.* Ottawa: Social Sciences and Humanities Research Council of Canada.

Aikenhead, G. S., & Ryan, A. G. (1992). The development of a new instrument: Views on science-technology-society (VOSTS). *Science Education, 76*(5), 477-491.

Ajzen, I., & Fishbein, M. (2005). The influence of attitudes on behavior. In D. Albarracin, B. T. Johnson & M. P. Zanna (Eds.), *The handbook of attitudes* (pp. 173-222). Mahwah: Lawrence Erlbaum Associates.

Alhassan, S. (2006). *Modern approaches to research in educational administration*. Kumasi: Payless Publication Ltd.

Amadalo, M. M., Ocholla, A. A., & Memba, E. B. (2012). Effect of Practical Work in Physics on Girls' Performance, Attitude change and Skills acquisition in the form two-form three Secondary Schools' transition in Kenya. *International Journal of Humanities and Social Science, 2*(23), 151.

Amunga, J. K., Musasia, M. A., & Musera, G. (2011). Disparities in the Physics Achievement and Enrolment in Secondary Schools in Western Province: Implications for Strategy and Renewal. *Problems of Education in the 21st Century*, *31*(31), 18-32.

APU (Assessment of Performance Unit) (1988). *Science at Age 15. A Review of APU Survey Findings 1980–84.* London: Her Majesty's Stationery Office.

Bagozzi, R. P., & Burnkrant, R. E. (1979). Attitude organization and the attitudebehavior relationship. *Journal of Personality and Social Psychology*, *37* (6), 913-929.

Baker, D. R. (1998). Equity issues in science education. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education*. Alphen ann, Nerthalands: Kluwer Academic Publishers.

Barron, B. J. S., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., & Bransford, D. J. (1998). Doing with understanding: lessons from research on problem and project-based learning, *The Journal of the Learning Sciences*, *7*, 271–311.

Bates, G. R. (1978). The role of the laboratory in secondary school science programs. In M. B. Rowe (Ed.), *What research says to the science teacher,* Washington, DC: National Science Teachers Association.

Beatty, J. W., & Woolnough, B. E. (1982). Practical work in 11–13 science: The context, type and aims of current practice. *British Educational Research Journal, 8* (1), 23–30.

Bennett, J. (2005). *Teaching and learning science: a guide to recent research and its application.* London: Continuum.

Bohner, G., & Wänke, M. (2002). *Attitudes and attitude change.* East Sussex: Psychology Press Ltd.

Buabeng, I., & Ntow, D. F. (2010). A Comparison study of students' reasons/views for choosing/not choosing physics between undergraduate female non-physics and female physics students at University of Cape Coast. *International Journal of Research in Education, 2*(2), 44-53.

Buabeng, I., Ossei-Anto, T. A., & Ampiah, J. G. (2014). An Investigation into Physics Teaching in Senior High Schools. *World Journal of Education 4*(5), 40-50. doi:10.5430/wje.v4n5p40

Campbell, R (2006). Teenage girls and cellular phones: discourses of independence, safety and 'rebellion'. *Journal of Youth Studies*, *9,* 195-212.

Chabalengula, V. M., Mumba, F., & Mbewe, S. (2012). How Pre-service Teachers' Understand and Perform Science Process Skills. *Eurasia Journal of Mathematics, Science & Technology Education, 8*(3), 167-176.

Chen, C. H., & Howard, B. (2010). Effect of live simulation on middle school students' attitudes and learning towards science. *Educational Technology and Society*, *13*(1), 133-139.

Donnelly, J., Buchan, A., Jenkins, E., Laws, P., & Welford, G. (1996). *Investigations by Order: Policy, Curriculum and Science Teachers' Work Under the Education Reform Act.* Nafferton: Studies in Education.

Driver, R. (1983). The fallacy of induction in science teaching: *The pupil as scientist.* Milton Keynes: Open University Press.

Driver, R. (1995). Constructivist approaches to science teaching. In L. P. Steffe & J. Gale (Eds), *Constructivism in Education* (pp. 385–400). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Duit, R., & Confrey, J. (1996). Reorganizing the Curriculum and Teaching to Improve Learning in Science and Mathematics. In D. F. Treagust, R. Duit & B. J. Fraser (Eds.), *Improving Teaching and Learning in Science and Mathematics* (pp 94–108). Columbia University, New York: Teachers College Press.

Durant, J., & Bauer, D. (1997). Public understanding of science: the 1996 survey. Paper presented at a seminar at the Royal Society, 8 December 1997.

Durant, J. R., Evans, G. A., & Thomas, G. P. (1989). The public understanding of science. *Nature*, *3*(40), 11–14.

Fadali, M .S., McNichols, K., & Robinson, M. (1999). Teaching Engineering To K-12 Students Using Role Playing Games, *Proceedings 1999 ASEE Annual Conference, Session 1526.*

Fraenkel, J. R.., & Wallen, N. E. (2000). *How to design and evaluate research in education*, (5th ed.). New York: McGraw-Hill Publishing Co.

Fraser, B. J. (2007). Classroom learning environments. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 103-125). Mahwah: Lawrence Erlbaum Associates.

Freedman, M. P. (1997). Relationship among laboratory instruction, attitude towards science and achievement in science knowledge, *Journal of Research in Science Teaching*, *34*, 343–357.

Freeman T. (2012). The Lancet highlights: Role of physics in medicine, *medicalphysicsweb*, April 20, http://www.iop.org/mt4/mt-tb.cgi/4415

Gardner, P. L. (1975). Attitudes to science: A review. *Studies in Science Education*, *2* (1), 1-41.

Garnett, P. J., & Hackling, M. W. (1995). Refocusing the chemistry lab: A case for laboratory-based investigations. *Australian Science Teacher Journal, 41*, 26-32.

Garwin, M. R., & Ramsier, R. D. (2003). Experiential learning at the university level: A US case study, *Education and Training, 45*(5), 280-285.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science, *Science Education*, *86*(5), 693-705.

González, N., & Moll, L. C. (2002). Cruzando el puente: Building bridges to funds of knowledge. *Educational Policy, 16*, 623-641.

Gott, R., Duggan, S., & Roberts, R. (2003). Understanding scientific evidence. Retrieved from http://www.dur.ac.uk/~ded0rg/Evidence/cofev.htm.

Greenwald, A. G. (1989). Why attitudes are important: Defining attitude and attitude theory 20 years later. In A. R. Pratkanis, S. J. Breckler & A. G. Greenwald (Eds.), *Attitude structure and function* (pp. 429-440). New Jersey: Lawrence Erlbaum Associates.

Gunstone, R. F. (1991). Reconstructing theory from practical experience. In Woolnough, B. E. (Ed.), *Practical Science* (pp. 67–77). Milton Keynes: Open University Press.

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

Hanif, M., Sneddon, P. H., Ahmadi, F. M. A., & Reid, N. (2009). The perceptions, views and opinions of university students about physics learning during undergraduate laboratory work. *European Journal of Physics*, *30*, 85-96.

Haussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching, 39*(9), 870-888.

Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, *52*(2), 201–217.

Hofstein, A. & Lunetta, V. N. (2004). The laboratory in science education: Foundation for the 21st century, *Science Education*, *88*, 28–54.

Hough, L. W., & Peter, M. K. (1982). The relationship between attitudes towards science and science achievement. *Journal of Research in Science Teaching*, *19*(1), 33-38.

House of Commons. (2002, July 11). *Select Committee on Science and Technology Third Report.* Retrieved January 15, 2012, from House of Commons Parliament: http://www.publications.parliament.uk/pa/cm200102/cmselect/cmsctech/508/50806.htm

House of Lords (2000). *Science and society,* London: Her Majesty's Stationery Office.

Jakeways, R. (1986). Assessment of A-level physics (Nuffield) investigations, *Physics Education*, *21*, 12–14.

Jenkins, E. W. (1994). Public understanding of science and science education for action. *Journal of Curriculum Studies*, *26*, 601–612.

Johnstone, A. H., & Al-Shualili, A. (2001). Learning in the laboratory; some thoughts from the literature, *University Chemical Education*, *5*, 42–50.

Joyce, B., Weil, M., & Calhoun, E. (2000). *Models of Teaching,* Boston: Allyn and Bacon.

Juceviciene P., & Karenauskaite V. (2004). Learning environment in physics: The context of double paradigm shift. Paper presented at the European Conference on Educational Research. Retrieved from http:// www.leeds.ac.uk/educol/documents/00003794.htm

Juriševič, M., Glažar, S. A., Pučko, C. R., & Devetak, I. (2008). Intrinsic Motivation of Pre service Primary School Teachers for Learning Chemistry in Relation to their Academic Achievement. *International Journal of Science Education*, *30*, 87–107.

Kelly, G. A. (1955). *The psychology of personal constructs*. New York: W.W. Norton.

Kempa, R. F., & Dube, G. E (1974). Science interest and attitude traits in students subsequent to the study of chemistry at the ordinary level of the G.C.E. *Journal of Research in Science Teaching*, *2*(4), 361-370.

Kerr, J. F. (1963). *Practical work in school science: an account of an inquiry sponsored by the Gulbenkian Foundation into the nature and purpose of practical work in school science teaching in England and Wales* (2nd ed.). Leicester: Leicester University Press.

Kibett, J. K., & Kathuri, N. J. (2005). Effects of projected-based learning on students' performance in secondary school Agriculture. *Zimbabwe Journal of Educational Research, 17*(1), 30-38.

Kim, M., & Chin, C. (2011). Pre-service teachers" views on practical work with inquiry orientation in textbook-oriented science classrooms. *International Journal of Environmental and Science Education, 6*(1), 23-37

Kim, M., & Song, J. (2009). The effects of dichotomous attitudes toward science on interest and conceptual understanding in physics. *International Journal of Science Education*, *31* (17), 2385-2406.

Kind, P. M. (1999). TIMSS Performance Assessment - a cross national comparison of practical work. In J. Leach & A. C. Paulsen (Eds), *Practical Work in Science Education – Recent Research Studies (*pp. 75–95). Dordrecht: Kluwer Academic Publishers.

Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education*, *29* (7), 871-893.

Klassen, S. (2009). Identifying and Addressing Pupil Difficulties with the Millikan Oil Drop Experiment. *Science & Education*, *18*, 593–607.

Klopfer, L. E. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings & G. F. Madaus (Eds.), *Handbook of formative and summative evaluation of student learning* London: McGraw-Hill.

Koballa Jr, T. R., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science learning. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education,* (pp. 75-102). London: Lawrence Erlbaum Associates.

Leach, J., & Scott, P. (1995). The demands of learning science concepts – issues of theory and practice. *School Science Review*, *76*(277), 47–51.

Lee, O., & Fradd, S. H. (2001). Instructional congruence to promote science learning and literacy development for linguistically diverse students. In D. R. Lavoie & W. M. Roth (Eds.), *Models of Science Teacher Preparation* (pp. 109-126). Netherlands: Kluwer.

Long, J. C. (1981). The effects of a diagnostic-prescriptive teaching strategy on student achievement and attitude in biology. *Journal of Research in Science Teaching*, *18*(6), 515 523.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Teaching and learning in the school science laboratory. An analysis of research, theory, and practice. In S. K. Abell & N. G. Lederman (Eds), *Handbook of Research on Science Education* (pp. 393–431). Mahwah, NJ: Lawrence Erlbaum Associates.

Lunetta, V. N. (1998). The school science laboratory: Historical perspectives and context for contemporary teaching. In B. Fraser and K. Tobin (eds.), *International handbook of science education* (pp. 349-264). Dordrecht: Kluwer Academic Publishers.

Lunetta, V. N., Hofstein, A., & Giddings, G. (1981). Evaluating science laboratory skills. *The Science Teacher, 48*(1), 22–25.

Maier, H. W. (2002). Role Playing: Structures And Educational Objectives, *The International Child and Youth Care Network*, Issue 36, Available at: http://www.cyc-net.org/cyc-online/cycol-0102-roleplay.html (Accessed: 5 July, 2013).

Mamlok-Naaman, R., Ben-Zvi, R., Hofstein, A., Menis, J., & Erduran, S. (2005). Learning science through a historical approach: Does it affect the attitudes of nonscience- oriented students towards science? *International Journal of Science and Mathematics Education*, *3* (3), 485-507.

McSharry, G., & Jones, S. (2000). Role-play in Science Teaching And Learning. *School Science Review*, *82*(298), 73-82.

Merrill, R. J., & Ridgway, D. W. (1969). *The CHEMStudy Story*. Freeman: San Francisco, 1969.

Millar, R. (2004, June 3-4). *The role of practical work in the teaching and learning of science.* Retrieved January 3, 2010, from University of York. http://www7.nationalacademies.org/bose/Millar_draftpaper_Jun_04.pdf.

Millar, R. (2009). *Analysing practical activities to assess and improve effectiveness: The Practical Activity Analysis Inventory (PAAI)*. University of York, Heslington, York

Mills, H. R. (1991). *Teaching and training: A handbook for instructors* (3rd ed.). London: Macmillan Publishers.

Ministry of Education. (2010). *Teaching syllabus for Physics: Senior High School* 1-3. Accra: Adwinsa Publications.

National Endowment for Science, Technology and the Arts (NESTA). (2005). *Science Teachers Survey*. London: NESTA. Available at: http://www.planetscience.com/sciteach/realscience/science_teachers_report.pdf (accessed on February 18, 2014).

Niaz, M., Abd-El-Khalick, F., Benarroch, A., Cardellini, L., Laburú, C. E., Marín, N., Montes, L. A., Nola, R., Orlik, Y., Scharmann, L.C., Tsai, C. C., & Tsaparlis, G. (2003). Constructivism: Defense or a Continual Critical Appraisal – A Response to Gil-Perez. *Science&Education, 12*, 787-797.

Okebukola, P. A. O. (1986). An investigation of some factors affecting students' attitudes toward laboratory chemistry. *Journal of Chemical Education, 86*, 531-532.

Oppenheim, A. N. (2000). *Questionnaire Design, Interviewing and Attitude Measurement.* London: Continuum Publishers.

Organisation for Economic Co-operation and Development (OECD). (2010). *Programme for international student assessment 2009 assessment framework: Key competencies in reading, mathematics and science.* Paris: OECD Publishing.

Ormerod, M. B., & Duckworth, D. (1975). *Pupils' attitudes to science: a review of research.* Berkshire: NFER Publishing Company.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. doi:10.1080/0950069032000032199

Piaget, J. (1978). *Success and Understanding*, in collaboration with M. Amann, C. L. Bonnet, M. F. Graven, A. Henriques, M. Labarthe, R. Maier, A. Moreau, C. Othenin-Girard, C. Stratz, S. Uzan and T. Vergopoulo. Transl. from the French by Arnold J. Pomerans. Translated from the French by Arnold J. Pomerans, London: Routledge and Kegan Paul.

Pickering, M. (1980). Are lab courses a waste of time? *The Chronicle of Higher Education, 19*, 80-94.

Pope, M., & Gilbert, J. (1983). Personal Experience And The Construction Of Knowledge In Science, *Science Education*, *67*(2), 193-203.

Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2007). Is biology boring? Student attitudes toward biology. *Journal of Biological Education*, *42*, 36–39.

Prokov, P., Tuncer, G., & Kvasničák, R. (2007). Short-term effects of field programme on students' knowledge and attitude toward biology: A Slovak experience. *Journal of Science Education and Technology*, *16*(3), 247-255.

Rajecki, D. W. (1990). *Attitudes* (2nd ed.). Massachusetts: Sinauer Associates Inc.

Ramsey, G. A., & Howe, R. W. (1969). An analysis of research on instructional procedures in secondary school science. *The Science Teacher, 36*, 72-81.

Reid, N. (2006). Thoughts on attitude measurement. *Research in Science and Technological Education, 24*(1), 3-27.

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2004). *A Review of Research on Outdoor Learning*, Preston Montford, Shropshire: Field Studies Council.

Rosenberg, M. J. (1960). An analysis of affective-cognitive consistency. In M.J. Rosenberg, C. L. Hovland., W. J. McGuire., R. P. Abelson & J. W. Brehm (Ed.), *Attitude organization and change: An analysis of consistency among attitude components* (pp.15-64). New Haven, CT: Yale University Press.

Rosenshine, B. (1997). Advances in research on instruction. In J. W. Lloyd, E .J. Kameenui & D. Chard (Eds), *Issues in educating students with disabilities* (pp. 197-221). Mahway, N. J: Lawrence Earlbaum,.

Saunders, W. L. (1992). The Constructivist Perspective: Implications and Teaching Strategies for Science. *School Science and Mathematics, 92*(3), 136-141.

Sharma, R., Rohilla R., Sharma, M., & Manjunath T. C. (2005). Design and Simulation of Optical Fiber Bragg gratting Pressure sensor for minimum attenuation criteria. *Journal of Theoretical and Applied Information Technology*, *5*, 515-530.

Sharpe, R. M. (2012). *Secondary school students' attitudes to practical work in school science*. Unpublished PhD Thesis, University of York Education.

Simpson, R. D., & Wasik, J. L. (1978). Correlation of selected affective behaviours with cognitive performance in a biology course for elementary teachers. *Journal of Research in Science Teaching*, *15*(1), 65-71.

Sjøberg, S. (2002). Science and technology education current challenges and possible solutions. In E. Jenkins (Ed.), *Innovations in Science and Technology Education* (Vol. VIII). Paris: UNESCO.

Stanley H. E. (2000). Exotic statistical physics: Applications to biology, medicine, and economics. *Physica A, 285*, 1-17.

Steven, J., & Atwood, R. (1978). Interest Scores as Predictors of Science Process Performance for Junior High School Students. *Science Education, 62*, 3303-308.

Talisayon, V. (2006). Science-Related Attitudes and Interests of Students. Paper presented in the IOSTE XII Symposium, Penang, Malaysia, August 1-4

Taylor, P. (1993). Collaborating to reconstruct teaching; The influence of researcher beliefs. In K. Tobin, (Ed.), *The practice of constructivism in science education* (pp. 267-297). Washington, DC: AAAS Press.

The Dainton Report. (2006). Report of the Committee of Enquiry into the Flow of Candidates in Sciences and Technology into Higher Education [The Dainton Report]. 1968. In J. Stuart Maclure (Ed.), *Educational Documents: England and Wales 1816 to the present day* (327-331). Oxon: Taylor and Francis.

Thompson, J., & Soyibo, K. (2002). Effects of lecture, teacher demonstrations, discussion and practical work on 10th grader's attitude to chemistry and understanding of electrolysis, *Research in Science and Technological Education*, *20*, 25–37.

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

Tifi, A., Natale, N., & Lombardi, A. (2006). Scientists at play: teaching Science Process skills, *Science in School 1*, 37-40.

Tobin, K. G. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics*, *90*, 403-418.

Tomažič, I. (2009). The influence of direct experience on pupils' attitudes to, and knowledge about amphibians. *Acta Biologica Slovenica*, *51*, 39–49.

Tomkins, S. P., & Tunnicliffe, S. D. (2001). Looking for ideas: Observation, interpretation and hypothesis-making by 12 year-old pupils understanding science investigations. *International Journal of Science Education, 23*(8), 791–813.

Toplis, R. & Allen, M. (2012). I do and I understand: Practical work and laboratory use in United Kingdom schools. *Eurasia Journal of Mathematics, Science & Technology Education, 8*(1), 3-9.

Toplis, R. (2012). Students' views about secondary school science lessons: The role of practical work. *Research in Science Education, 42* (3), 531-549.

Trowbridge, L. W., Bybee, R. W., & Powell, J. C. (2000). *Teaching Secondary School Science*, Upper Saddle River, NJ: Merrill / Prentice Hall.

Trumper, R. (2003). The Physics Laboratory – A Historical Overview and Future Perspectives. *Science & Education 12*, 645–670.

Uwaifo, V. O. (2012). A Comparative Study of Students Performance in Technology based Theory and Practical Subjects in Nigerian Universities. *International Journal of Scientific & Technology Research*, *1*(1), 1-3.

W.A.E.C. (2011). *Chief Examiner's Report*. Accra: W.A.E.C. Press Ltd.

Walberg, H. J. (1991). Improving School Science in Advanced and Developing Countries. *Review of Educational Research*, *61*, 25-69.

Wasanga, P. M. (2009). The role of examination results as a feedback tool: The Kenyan Experience. Paper presented at First READ Global Conference: Developing a Vision for Assessment Systems, Kenya. Retrieved from http://www.siteresources.worldbank.org/EDUCATION/Resources/278200-1256666213814/Updated_READ_GC_Presentation_14_PWasanga_Eng.pdf

Watson, J. R., Prieto, T., & Dillon, J. (1995). The effects of practical work on students' understanding of combustion. *Journal of Research in Science Teaching, 32*, 487–502.

Watson, R., Wood-Robinson, V., & Nikolaou, L. (2006). Better scientific enquiries. In V. Wood Robinson (Ed.), *ASE guide to secondary science education* (pp. 196-204). Hatfield: Association for Science Education.

Wellington, J. (2005). Practical work and the affective domain: what do we know, what should we ask, and what is worth exploring further? In S. Alsop (Ed.), *Beyond Cartesian dualism: Encountering affect in the teaching and learning of science: Volume 29 of Science and technology education library* (pp. 99-110). New York,NY: Springer.

Wellington, J. (Ed.). (1998). *Practical Work in School Science. Which Way Now?* London: Routledge.

Wenham E. J., Dorling G., Snell J. A. M., & Taylor B. (1984). *Physics: Concepts and Models*. London: Addison Wesley.

White, R. T. (1988). *Learning science.* Oxford: Blackwell

White, R. T., & Gunstone, R. F. (1992). *Probing Understanding.* London: Falmer Press.

Wilson, T. D., Lindsey, S., & Schooler, T. Y. (2000). A model of dual attitudes. *Psychological Review, 107* (1). 101-126.

Woodley, E. (2009). Practical work in school science: why is it important? *School Science Review, 91* (335), 49-51.

Woolnough, B. E. (1994). *Effective Science Teaching*. Buckingham: Open University Press.

Woolnough, B. E. (1998). Authentic science in schools, to develop personal knowledge. In J. Wellington (Ed.), *Practical work in school science: Which way now?* (pp. 109-125). London: Routledge.

Zain, A. N. M., Rohandi, R., Jusoh, A., & Samsudin, M. A. (2010), Improving Students' Attitudes Toward Science Using Instructional Congruence. *Journal of Science and Mathematics Education in Southeast Asia*, *33*(1), 39-64.

Zhaoyao, M. (2002). Physics Education for the 21st Century: Avoiding a Crisis. *Physics Education*, *37*(1), 18-24.

APPENDICES

APPENDIX A

Pre-Test

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA

END OF 3RD TERM EXAMINATION – 2013

PHYSICS - S.H.S. ONE

TIME 2 HOURS

1. Which of the following physical quantities are derived?

   I. Area II. Thrust III. Pressure IV. Mass

   [a] I, II and IV [b] I, II and III only [c] I, II, III and IV [d] I and III only

2. A block of volume $3x10^5m^3$ and density $2.5 \times 10^3kgm^{-3}$ is suspended from a spring balance with 2/3 of its volume immersed in a liquid of density $900kgm^{-3}$. Determine the reading of the spring balance [$g = 10ms^{-2}$]

   [a] 0.18N [b] 0.57N [c] 18×10^8N [d] 57×10^8N

3. A piece of iron has a volume of $15cm^3$ and a mass of 27g. Calculate the density of iron in kg/m^3

   [a] $1.8kgm^{-3}$ [b] $180kgm^{-3}$ [c] $0.55kgm^{-3}$ [d] $1800kgm^{-3}$

4. If $25cm^3$ of a quantity of marbles has a mass of 45g, calculate the density of the marble in kgm^{-3}

   [a] $1800kgm^{-3}$ [b] $1.8kgm^{-3}$ [c] $70kgm^{-3}$ [d] $0.56kgm^{-3}$

5. A liquid has a relative density of 12.2. Calculate its density. (Density of water is $1x10^3kgm^{-3}$)

   [a] $1220kgm^{-3}$ [b] $12200kgm^{-3}$ [c] $0.0122kgm^{-3}$ [d] $12.2kgm^{-3}$

6. A piece of metal weighs 90g. When it is put in a measuring cylinder containing water, the water level rises from 45cm^3 mark to the 85cm^3 mark. Find the density of the metal

[a] 2gcm^{-3} [b] 1.05gcm^{-3} [c] 2.25gcm^{-3} [d] 0.4gcm^3

7. A lump of gold has a density of 6gcm^{-3} and volume of 24cm^3. Calculate the mass of the gold

[a] 4g [b] 0.25g [c] 30g [d] 144g

8. Find the density of the material of a sphere of radius 0.3m if the mass is 28kg, (π= 22/7)

[a] 1037.04kgm^{-3} [b] 247.57kgm^{-3} [c] 98.98kgm^{-3} [d] 329.97kgm^{-3}

9. Find the density of a glass cylinder of base radius 0.1m and height 0.5m if the mass of the cylinder is 44kg. [π=22/7)

[a] 2800kgm^{-3} [b] 10500kgm^{-3} [c] 880kgm^{-3} [d] 280kgm^{-3}

10 Solid weighs 0.040N in air and 0.024N when fully immersed in a liquid of density 800kgm^{-3}. What is the volume of the solid? (g = 10ms^{-2})

[a] 2.0x10^{-6}m^3 [b] 2.5 x 10^{-6}m^3 [c] 2.0 x 10^{-5}m^{-3} [d] 3 x 10^{-6}m^3

11 The density of water is 1gcm^{-3} while that of ice is 0.9gcm^{-3}. Calculate the change in volume when 90g of ice is completely melted

[a] 100cm^3 [b] 9cm^3 [c] 10cm^3 [d] 90cm^3

12 The density of lead is 11.3gcm^{-3}. What is this value in kilograms per cubic metre?

[a] 0.0113kgm^{-3} [b] 11300kgm^{-3} [c] 1.13 x 10^{10}kgm^{-3} [d] 11.3kgm^{-3}

13 How many years older will you be 1 billion seconds from now? [Assume a 365 – day year]

[a] 30 years [b] 31.7 years [c] 28 years [d] 33 years

14 A fish tank measures 40cm x 20cm x 25cm inside. What is the mass of water it holds when it is full to the brim? [Density of water =1000kgm^{-3}]

[a] 20000kg [b] 20kg [c] 200kg [d] 2000kg

15 Determine the distance covered by a body in 4.0s if its initial velocity is 20ms^{-1} and acceleration is 4ms^{-2}

[a] 880m [b] 36m [c] 112m [d] 200m

16 A body initially travelling at 10ms^{-1} is given a retardation of 2ms^{-2} for 3s. Find its final velocity

[a] 16ms^{-1} [b] 6ms^{-1} [c] 20ms^{-1} [d] 4ms^{-1}

17 A body starts from rest and travelled after 10s 200m. Find its acceleration

[a] 6ms^{-2} [b] 4ms^{-2} [c] 8ms^{-2} [d] 10ms^{-2}

18 A vehicle is moving at 5ms^{-1}. How long will it take to stop at a distance of 15m?

[a] 6s [b] 5s [c] 10s [d] 20s

19 A body starts with an initial velocity 26ms^{-1} and moves with a constant acceleration of 7ms^{-2} for 25s. Find the total distance moved in metres.

[a] 25m [b] 115m [c] 2837.5m [d] 1689m

20 An electric train moving at 20kmh^{-1} accelerates to a speed of 30kmh^{-1} in 20s. Find the distance travelled during the period of acceleration.

[a] 138.9m [b] 125m [c] 500m [d] 240m

21 A car moving with a speed of 90kmh^{-1} was brought uniformly to rest by the application of brakes in 10s. How far did the car travel after the brakes were applied?

[a] 375m [b] 150m [c] 450m [d] 125m

22 A stone is dropped down a well, if it takes 5s to reach the surface of the water, how deep is the well? [g = 10ms^{-2}]

[a] 50m [b] 125m [c] 85m [d] 60m

23 A rocket is fired vertically upwards and reaches the height of 400m. How long does it take to reach the maximum height? [g = $10ms^{-2}$]

[a] 10s [b] 5s [c] 8.9s [d] 5.65s

24 A stone is thrown vertically upwards from the top of a tower 50m high with an initial velocity of $20ms^{-1}$. Calculate the maximum height the stone reached from the ground. [g = $10ms^{-2}$]

[a] 20m [b] 50m [c] 200m [d] 70m

25 A ball is thrown upwards on the moon with an initial speed of $35ms^{-1}$. Calculate its velocity 3s after it has been thrown. [g on the moon = $1.6ms^{-2}$]

[a] $30.2ms^{-1}$ [b] $5ms^{-1}$ [c] $65ms^{-1}$ [d] $21.9ms^{-1}$

26 A palm fruit dropped to the ground from the top of a tree 45m tall. How long does it take to reach the ground? [g = $10ms^{-2}$]

[a] 3s [b] 9s [c] 6s [d] 12s

27 A ball is thrown vertically upwards from the ground with an initial velocity of $50ms^{-1}$. Calculate the highest distance it reaches. [g = $10ms^{-2}$]

[a] 125m [b] 375m [c] 180m [d] 96m

28 A body which was on an inclined plane, made an angle of 45^o to the horizontal moved from rest along the plane for 10s. Find its distance travelled after the 10s period. [g = $10ms^{-2}$]

[a] 353.55m [b] 70.7m [c] 10m [d] 300m

29 A ball is thrown up a smooth inclined plane with initial velocity of $54kmh^{-1}$. If the inclination of the plane is 30^o. Find the maximum height reached. [g = $10ms^{-2}$]

[a] 22.5m [b] 15m [c] 28m [d] 67.5m

Use the information below to answer question 30-33.

A particle is projected from the ground level with speed $30ms^{-1}$ at an angle of 30^o to the horizontal. [$g=10ms^{-2}$], calculate

30 The time of flight is ………………

[a] 3s [b] 9s [c] 6s [d] 22.5s

31 The range is ……………….

[a] 30m [b] 77.94m [c] 51.96m [d] 11.25m

32 The time taken to reach the greatest height is ………………..

[a] 3s [b] 1.5s [c] 9s [d] 6s

33 The greatest height is ……………

[a] 22.5m [b] 11.25m [c] 77.94m [d] 50m

34 A stone is projected horizontally from a height of 20m above the ground with an initial velocity of $0.4ms^{-1}$. Calculate the horizontal distance moved by the stone before striking the ground. [$g = 10ms^{-2}$]

[a] 16m [b] 0.8m [c] 1.6m [d] 4m

35 Two forces 3N and 4N act on a body. If the angle between the forces is 60^o, calculate the magnitude of the resultant force on the body.

[a] 37N [b] 6.08N [c] 13N [d] 45N

36 A ball is thrown downwards with a velocity of $20ms^{-1}$ from the top of a cliff of 35m. Find the velocity of the ball just before it hits the ground. [$g = 10ms^{-2}$]

[a] $400ms^{-1}$ [b] $1100ms^{-1}$ [c] $33.17ms^{-1}$ [d] $66.34ms^{-1}$

37 A ball is thrown vertically upwards with a velocity of $25ms^{-1}$. Find its height when it is moving with velocity of $15ms^{-1}$. [$g = 10ms^{-2}$]

[a] 40m [b] 30m [c] 20m [d] 10m

38 Two forces of 20N and 40N act at a point and the angle between them is 30^o. Find the resultant force

[a] 24.79N [b] 3385.6N [c] 614.35N [d] 58N

39 A cyclist moves 20km north and then 35km east on a horizontal road. How far is he from the starting point?

[a] 63.4N [b] 2675N [c] 51.72N [d] 40.31N

40 The distance travelled by a body, falling freely from rest in one, two and three seconds are in the ratio ………… [$g = 10ms^{-2}$]

[a] 1:2:3 [b] 1:3:5 [c] 9:4:1 [d] 1:4:9

41 The acceleration of a moving body can be found from

[a] area under velocity – time graph [b] area under distance – time graph

[c] Slope of the velocity – time graph [d] slope of the distance – time graph

42 The distance covered by a moving object can be found from

[a] area under velocity – time graph [b] area under distance – time graph

[c] Slope of the velocity – time graph [d] slope of the distance – time graph

43 At the top of a trajectory, a projectile has zero vertical velocity but its vertical acceleration is still

[a] +g [b] –g [c] –y [d] +x

44 What will happen to an object thrown into the sky and attains a zero velocity and zero acceleration

[a] it will continue in the sky [b] it will fall back to the ground

[c] it will remain there forever [d] the birds will take it away

45 Two forces F_1 and F_2 act on a particle. F_1 has magnitude 5N and in direction 030^0, and F_2 has magnitude 8N and in direction 090^o. Find the magnitude and direction of their resultant.

[a] (8.5N; 81^o) [b] (7.59N; 105.6^o)

[c] (10.36N; 067.6^o) [d] (11.36N; 067.6^o)

46 Two forces F_1 and F_2 act on a particle F_1 has magnitude 6N and in direction 045°, and F_2 has magnitude 7N and in direction 154°, find the magnitude and direction of their resultant.

[a] (750N, 105.6°) [b] 7.59N; 105.6°)

[c] (7.59N; 41.4°) [d] 17.59; 105.6°)

47 Two forces of magnitudes 10N and 12N act on a particle. If the angle between them is 60°, find the magnitude and direction of their resultant.

[a] (19.08N; 33°) [b] (19.08N; 80°)

[c] (41.2N; 105.6°) [d] (80N; 33°)

48 Two forces of 20N and 40N act at a point and the angle between them is 30°. Find the resultant force

[a] 58N [b] 36.9N [c] 54N [d] 52.9N

49 Express the vector (20N, 240) into horizontal and vertical component

[a] (-17.32N; -10N) [b] (-10N, - 17.32N)

[c] (10.4N, 17.32N) [d] (6N, - 10N)

50 Express the vector (12N, 330°) in horizontal and vertical component

[a] (-6N, 10.4N) [b] (6N, 10.4N)

[c] (-10.4N, 6N) [d] (10.4, - 6N)

SECTION 'B'

Answer ALL questions

1. State the law of floatation

2. Name four units to measure extremely small distances

3. The force F acting on a body moving in a circular path depends on mass m of the body and squared of the velocity and inversely proportional to the radius r of the circular path. Obtain an expression for the force by dimensional analysis.

4. [a] A body at rest is given an initial uniform acceleration of $8ms^{-2}$ for 30s, after which the acceleration is reduced to $5ms^{-2}$ for the next 20s. The body maintains the speed attained for 60s after which it is brought to rest in 20s.

   Draw the velocity – time graph of the motion using the information given above

   Using the graph calculate the:

   [b] Maximum speed attained during the motion

   [c] Average retardation as the body is being brought to rest

5. A particle is projected from the ground level with speed 40m/s at an angle of σ to the horizontal, where σ = ¾, calculate

   i. The time of flight

   ii. The range

   iii. The time taken to reach the greatest height

   iv. The greatest height

6. Draw the forces acting on an object at equilibrium on an inclined plane.

GOOD LUCK.

APPENDIX B

STUDENTS' QUESTIONNAIRE

THE EFFECT OF PRACTICAL WORK ON STUDENTS' UNDERSTANDING

INSTRUCTIONS

Thank you for taking time to complete this questionnaire. Please respond to each of the items to the best of your ability. Your thoughtful and truthful responses will be greatly appreciated. **Your individual name or any identification number is <u>not required</u> and will not at any time be associated with your responses.** Your responses will be kept completely **<u>confidential</u>** and will not influence your course grade and any of your examination results anywhere.

Please read the following statements and kindly provide the information required.

A. Background information

Please tick [✓] in the appropriate space provided below and supply answers where required.

1. Gender: [ ] Female [ ] Male

2. Age ………………years

3. What is your pre-entry qualification?

[ ] MSLCE [ ] BECE

Please other, specify……………………………………………………………………

B. Perception of students attitudinal change towards physics after exposure to practical work

Please, tick [√] the option that best reflects how you associate with each of the following statements.

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

Statement	SA	A	N	D	SD
4. Performing practicals enhances my understanding in the topic treated.					
5. I get excited whenever we perform practicals and wish we do practicals everyday during physics lessons.					
6. I am able to express my ideas and analysed situations very well after performing practical work					
7. I get to understand how some things work in everyday life activities during practical lessons.					

C. Perceptions of students on acquired Basic science process skills

Please, tick [✓] the option that best reflects how you associate with each of the following statements.

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

Statement	SA	A	N	D	SD
8. Performing practicals have increased my confidence in measuring physical quantities and reading values.					
9. Since we started performing practicals I have become increasingly aware of things in my environment.					
10. It's now easy for me to indicate measured quantities in their appropriate units					

D. Perceptions of the effectiveness of Practical work to students understanding.

Please, tick [✓] the option that best reflects how you associate with each of the following statements.

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

Statement	**SA**	**A**	**N**	**D**	**SD**
11. I was more enthusiastic and motivated during the use of practical work in the teaching and learning of the taught concepts.					
12. The use of practical work as instructional techniques is an effective strategy for students of all abilities					
13. The use of practical work during instruction reduces my personal interaction with my colleagues.					
14. The use of practicals makes me feel like I am lost in a jumble of numbers and words					
15. The use of practical work as instructional strategy would promote students understanding of concept and do away rote learning as well as memorization of facts.					
16. Practicals hinder students' ability with learning tasks (e.g., writing, analyzing data, or solving problems).					
17. The use of practical work as instruction is an effective means of helping students to understand theories laws and principles.					

Statement	SA	A	N	D	SD
18. Doing practicals make me feel more involved in the learning process.	____	____	____	____	____
19. The use of practicals as an instructional method reduces forgetfulness and recitation of mnemonics as well as acronyms during examinations.	____	____	____	____	____
20. The use of practicals for instruction would enable me to interact more with my colleague to promote group discussion.	____	____	____	____	____
21. I think performing practicals in Physics is a waste of time.	____	____	____	____	____
22. I always enjoy the lesson when our teacher makes us do practicals.	____	____	____	____	____
23. I will be glad if we do practicals in all our lessons in physics.	____	____	____	____	____

(24) Please, give your general view(s) about the Perceptions of the effectiveness of practical work integration in the teaching and learning of physics as a practice to enhance students' performance in the study of physics in the space below:

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Thank you very much for your assistance and time

APPENDIX C1

Post-test

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA

END OF MONTH EXAMINATION – 2014

PHYSICS - S.H.S. TWO

TIME 1 HOUR

Answer All questions

1. The temperature at which pure ice melts at standard atmospheric pressure is known as

   [a] Vapour pressure [b] Ice point

   [c] Latent heat of fusion [d] Melting point

2. Which of the following statements about thermometers is not correct?

   [a] A clinical thermometer cannot be used to measure temperatures above 34°C

   [b] An alcohol thermometer cannot be used to measure the temperature of palm wine boiling at normal atmospheric pressure.

   [c] A mercury-in-glass thermometer can be used to measure a temperature of 300°C.

   [d] A mercury thermometer cannot be used to measure temperature below -41°C.

3. Temperature is a measure of

   [a] the total kinetic energy of the molecules

   [b] the average kinetic energy of the molecules

   [c] the quantity of the heated matter

   [d] the total kinetic and potential energy of the molecules

4. The direction of heat flow between two bodies is determined by

   [a] the direction of the wind

   [b] the mass of each body

[c] the temperature difference of the two bodies

[d] the coefficients of expansion of the bodies

5. Which of the following can produce heat energy?

(i) Friction (ii) chemical reactions (iii) the sun's rays (iv) nuclear energy

[a] (i) and (ii)

[b] (i), (ii), (iii) and (iv)

[c] (i) and (iii)

[d] (ii) only

6. Which of the following occurs as a result of the expansion of substances?

I. the sag in telephone wires or electric power lines

II. breaking of the contact in an electric iron

III. the separation of the mercury thread in a thermometer

[a] I and II [b] II and III

[c] I, II and III [d] III only

7. (a) What is the difference between heat and temperature?

(b) List four ways of producing heat, and state how each is used in the home.

8. What is the difference between evaporation and boiling?

9. The distance between the lower and upper fixed points on a thermometer is 106 mm. Calculate the temperature recorded in °C when the length of the mercury thread is 70.2 mm above the lower fixed point.

10 A metal cube takes 5 minutes to cool from 60^{o} C to 52^{o} C. How much time will it take to cool to 44^{o} C, if the temperature of the surroundings is 32^{o} C?

APPENDIX C2

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA

END OF MONTH EXAMINATION – 2014

PHYSICS - S.H.S. TWO

TIME 1 HOUR

Answer All questions

1. In the simple voltaic cell the element that is used for the negative pole is

   [a] zinc [b] copper

   [c] brass [d] carbon rod

2. An electrical device which sets the electrons in motion when the electrons are connected to a conductor is the

   [a] ammeter [b] electrodes [c] electrolyte [d] cell

3. Which of the following cannot generate an electromotive force to move electrons through a conductor?

   I. Primary cell II. Secondary cell III. Photovoltaic cell IV. Solar cell

   [a] I and II [b] I, II, III and IV [c] III and IV [d] None of the above

4. The simple voltaic cell contain dilute tetraoxosulphate (iv) acid through which electrons flow into the terminals. A fluid which conducts electrons is known as:

   [a] a conductor [b] an electrolyte [c] a battery [d] a cell

5. Which of the following are indications that electrons are flowing in a circuit?

   I. deflection of the dial of an ammeter

   II. Lighting a bulb

   III. a magnetic field around the conductor

   [a] I and II [b] II and III [c] I, II and III [d] II only

6. The defect in a simple cell which results in a back emf and increases the cell's internal resistance is referred to as:

[a] reduction [b] polarization

[c] local action [d] depolarization

7. A 12V accumulator can be used to operate a car but a 20V primary battery cell cannot. The reason is that:

[a] Primary cells have low internal resistance

[b] Polarization runs the dry cell down

[c] The low internal resistance of the accumulator as well as provision for depolarization enables it to function effectively and allow free flow of electrons

[d] Accumulators are heavier than primary cells

8. a) Draw and label a diagram of the Daniel cell

b) What are the main defects of Daniel cell and how are they minimised

9. a) What is a primary cell?

b) Describe how a dry cell discharges current.

10 a) Explain why an unripe lemon can be a source of electricity.

b) Which factor in the electrolyte of a wet voltaic cell can be identified in the lemon?

APPENDIX C3

Post-test

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA

END OF MONTH EXAMINATION – 2014

PHYSICS - S.H.S. TWO

TIME 1 HOUR

Answer All questions

1. The earliest magnet discovered was an ore of iron oxide (Fe3O4). This stone is called

   [a] a bar magnet [b] marble stone

   [c] lodestone [d] an electromagnet

2. Which of the following are magnetic substances?

   I. Iron II. Steel III. Copper IV. Cobalt

   [a] I and II [b] I, II and IV [c] I and III [d] I, II, III and IV

3. For which of the following substances, the magnetic susceptibility is independent of temperature?

   [a] Diamagnetic

   [b] Paramagnetic

   [c] Ferromagnetic

   [d] Diamagnetic and paramagnetic

4. Which of the following best describes a magnetic domain?

   [a] a region of zero resistance to the flow of electrons

   [b] a region of infinite resistance to the spinning of electrons

   [c] a region where the magnetic fields of the atoms are lined up in a specific direction

   [d] a region where some atoms are magnetic while others are non-magnetic

5. In a bar magnet with consequent poles

   [a] one pole is stronger than the other when used to pick up nails

   [b] no field of force exists around it

   [c] two like poles are located at the centre and the ends

   [d] the inductive strength is completely zero

6. a) What is meant by magnetic flux and neutral point of a magnetic field? Sketch diagrams to illustrate the answer.

7. Explain why it is said that the Earth behaves like a magnet

8. Two bar magnets are placed on a horizontal surface with their north poles facing each other. Sketch the lines of force between them.

9. List four features of magnetic line of force

10 Distinguish between ferromagnetic substances and ferrites.

APPENDIX C4

Post-test

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA

END OF TERM EXAMINATION – 2014

PHYSICS - S.H.S. TWO

TIME 2 HOURS

1. Which of the following will radiate heat to the large extent?

   [a] White polished surface [b] white rough surface

   [c] Black polished surface [d] black rough surface

2. A block of ice in a room at normal temperature

   [a] Does not radiate

   [b] Radiates less but absorbs more

   [c] Radiates more than it absorbs

   [d] Radiates as much as it absorbs

3. For which of the following substances, the magnetic susceptibility is independent of temperature?

   [a] Diamagnetic

   [b] Paramagnetic

   [c] Ferromagnetic

   [d] Diamagnetic and paramagnetic

4. At Curie temperature, a ferromagnetic material becomes

   [a] Non−magnetic [b] diamagnetic

   [c] Paramagnetic [d] strongly ferromagnetic

5. Electromagnets are made of soft iron because soft iron has

[a] Low susceptibility and low retentivity

[b] High susceptibility and low retentivity

[c] High susceptibility and high retentivity

[d] Low permeability and high retentivity

6. According to the kinetic theory of gases, which of the following properties of a gas can be affected by the collision of the gas molecules with the walls of its container?

[a] Temperature [b] Energy [c] Viscosity [d] Pressure

7. Which of the following statements is not correct?

[a] A magnetic field is a region in which a magnetic force may be detected

[b] A magnetic line of force is a path along which a magnetic north-pole would move if it were free

[c] Magnetic fields are scalar quantities

[d] Neutral points are obtained where the earth's magnetic field is exactly equal and opposite to that due a magnet.

8. The earliest magnet discovered was an ore of iron oxide (Fe3O4). This stone is called

[a] a bar magnet [b] marble stone

[c] lodestone [d] an electromagnet

9. Which of the following are magnetic substances?

I. Iron II. Steel III. Copper IV. Cobalt

[a] I and II [b] I, II and IV [c] I and III [d] I, II, III and IV

10. Which of the following best describes a magnetic domain?

[a] a region of zero resistance to the flow of electrons

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[a] one pole is stronger than the other when used to pick up nails

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[d] the inductive strength is completely zero

12. In the simple voltaic cell the element that is used for the negative pole is

[a] zinc [b] copper

[c] brass [d] carbon rod

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[a] ammeter [b] electrodes [c] electrolyte [d] cell

14. Which of the following cannot generate an electromotive force to move electrons through a conductor?

I. Primary cell II. Secondary cell III. Photovoltaic cell IV. Solar cell

[a] I and II [b] I, II, III and IV [c] III and IV [d] None of the above

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[a] a conductor [b] an electrolyte [c] a battery [d] a cell

16. Which of the following are indications that electrons are flowing in a circuit?

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II. Lighting a bulb

III. a magnetic field around the conductor

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[c] local action [d] depolarization

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[b] Polarization runs the dry cell down

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[c] Latent heat of fusion [d] Melting point

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[c] A mercury-in-glass thermometer can be used to measure a temperature of 300°C.

[d] A mercury thermometer cannot be used to measure temperature below -41°C.

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[a] the total kinetic energy of the molecules

[b] the average kinetic energy of the molecules

[c] the quantity of the heated matter

[d] the total kinetic and potential energy of the molecules

22. The direction of heat flow between two bodies is determined by

[a] the direction of the wind

[b] the mass of each body

[c] the temperature difference of the two bodies

[d] the coefficients of expansion of the bodies

23. Which of the following can produce heat energy?

(i) Friction (ii) chemical reactions (iii) the sun's rays (iv) nuclear energy

[a] (i) and (ii)

[b] (i), (ii), (iii) and (iv)

[c] (i) and (iii)

[d] (ii) only

24. Which of the following occurs as a result of the expansion of subsatances?

I. the sag in telephone wires or electric power lines

II. breaking of the contact in an electric iron

III. the separation of the mercury thread in a thermometer

[a] I and II [b] II and III

[c] I, II and III [d] III only

25. The area around a magnet or a current carrying coil where magnetic strength can be detected with a compass is called

[a] magnetic domain [b] induced field [c] magnetic field [d] magnetic poles

26. What kind of rays do solar cells depend on for their effective function?

[a] cathode rays [b] X-rays [c] the sun's rays [d] beta rays

27. Which substance is responsible for polarising in the primary cell?

[a] oxygen [b] hydrogen bubbles [c] manganese oxide [d] carbon

28. To forestall local action the manufacturer of the cell

[a] coats the surface of the zinc plate with mercury

[b] adds a depolariser to the electrolyte

[c] eliminates all the impurities from the zinc plate

[d] boils the electrolyte

29. The Daniell cell is used as a standard cell because:

[a] it possesses all the qualities of a primary and secondary cell

[b] it has a depolariser to control local action as well as polarisation

[c] it can produce a constant emf of 1.1V for several hours

[d] it contains a sulphate solution which is an electrolyte.

30. The part of the modern Leclanche cell which prevents evaporation of water from the ammonium chloride solution is:

[a] the plastic washer and the bitumen seal

[b] the manganese (iv) oxide and the carbon powder

[c] the steel jacket covering the zinc case

[d] the zinc case

31. An iron bar 2 m in length is heated from 20°C to 370°C. What is its new length?

[a] 2.0084m [b] 2.8400m [c] 4.0084m [d] 0.0084m

32. Which of the following types of thermometer have to be in thermal equilibrium with the object being measured in order to give accurate readings?

I. a bimetallic strip II. a resistance thermometer III. a temporal artery thermometer

[a] I and III [b] II and III [c] I and II [d] II only

33. Rank the following temperatures from highest to lowest:

I. 0.00°C II. 0.00°F III. 260°K IV. -180.0°C

[a] I, III, II, IV [b] IV,II,I and III [c] II, I, IV and III [d] IV, II, III and I

34. Which of the following materials are attracted to a magnet?

I. Sodium II. Bismuth III. Lead IV. Cerium

[a] II, III and IV [b] I and IV [c] I and III [c] II and III

35. Which of the following substances is not an insulator?

[a] aluminium [b] glass [c] cork [d] clay

36. A mercury in glass thermometer reads -20° at the ice point and 100° at the steam point. Calculate the length if the corresponding temperature is 70° on the thermometer.

[a] 75.0cm [b] 50.0cm [c] 58.0cm [d] 84cm

37. Which of the following surfaces will radiate heat energy best?

[a] White surface [b] Black surface [c] Red surface [d] Green surface

38. In the electrical method of magnetisation, the polarity of the magnet depends on the

[a] Magnetic material used [b] Direction of current

[c] Amount of current passed [d] size of the magnetic material

39. The direction of the magnetic field at a point in the vicinity of a bar magnet is

[a] along the line joining the point to a neutral point

[b] the direction towards which the north pole of a compass needle would point

[c] always towards the north pole of the magnet

[d] always away from the south pole of the magnet

40. The region around magnet in which the magnetic influence is experienced is called

[a] magnetic flux [b] magnetic declination

[c] magnetic field [c] magnetic meridian

SECTION B

1. a) Two rods A and B of different material have equal length and equal temperature gradient. Each rod has its ends at temperatures T1 and T2. Find the condition under which rate of flow of heat through the rods A and B is same.

   b) A metal cube takes 5 minutes to cool from 60° C to 52° C. How much time will it take to cool to 44° C, if the temperature of the surroundings is 32° C?

   c) Explain why there is no temperature change when a solid being heated changes into liquid at its melting point.

2. a) Distinguish between dia-, para- and ferro- magnetic substances. Give one example for each.

   b) Two bar magnets are placed on a horizontal surface with their north poles facing each other. Sketch the lines of force between them.

   c) How is artificial magnet prepared from natural magnet?

3. a) i. Name and explain the common defects of a primary cell

   ii. State two advantages of a secondary cell over a primary cell

b) Draw a labelled diagram to show the essential parts of a dry leclanche cell.

c) Explain why six accumulators each of e.m.f 2V connected in series can be used to start the engine of a car whereas eight dry cells of e.m.f 1.5V connected in series cannot be used.

d) Name the materials used for the positive terminal, the negative terminal and the electrolyte in a

I. Leclanche cell

II. Charged lead acid accumulator

APPENDIX D1

ANSWERS FOR PRE-TEST

1.B	2.A	3.D	4.A	5.B	6.C	7.D	8.B	9.A	10.C	11.C	12.B
13.B	14.B	15.C	16.D	17.B	18.A	19.C	20.A	21.D	22.B	23.C	24.D
25.A	26.A	27.A	28.A	29.A	30.A	31.B	32.B	33.B	34.B	35.B	36.C
37.C	38.D	39.D	40.D	41.C	42.A	43.B	44.C	45.D	46.B	47.A	48.A
49.A	50.A										

SECTION B

1. The law of floatation states that a floating body will displace its own weight of the fluid in which it floats.
2. I. Femtometer II. Picometer III. Nanometer IV. Micrometer V. Millimeter
3.

$$F \propto \frac{mv^2}{r}$$

$$F = K\frac{mv^2}{r}$$

But K is a dimensionless constant, [Mass]= M, [Velocity]=LT^{-1}, [r]=L

$$F = \frac{ML^2 T^{-2}}{L}$$

$$F = MLT^{-2}$$

4. v= u + at

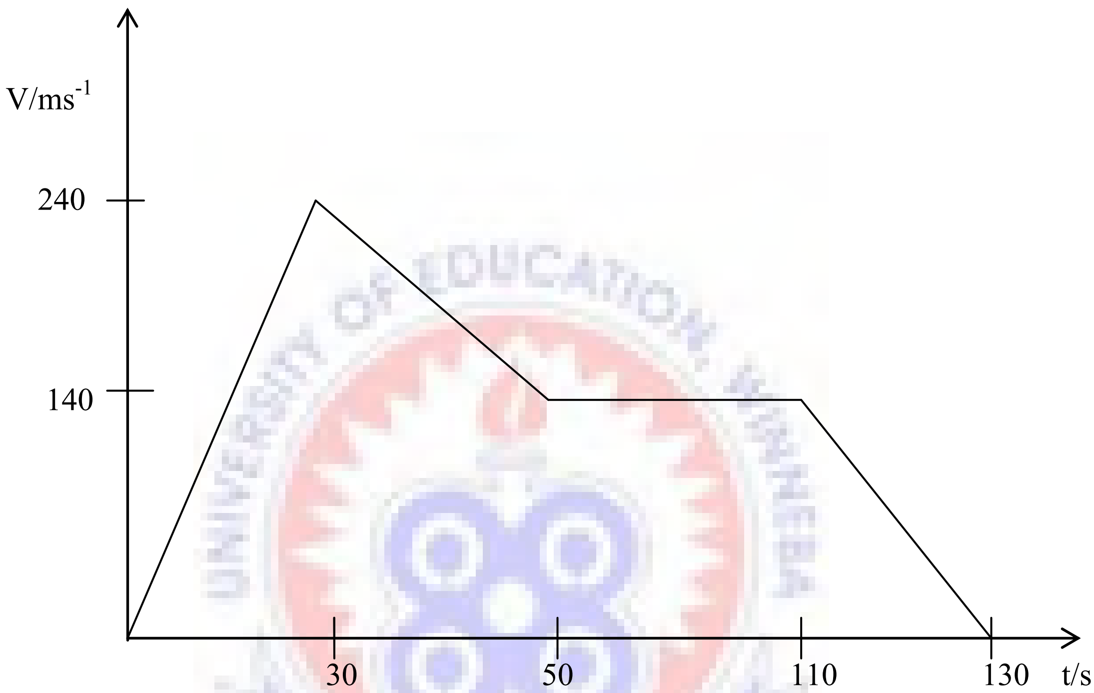
v= 0 + 8(30)

v= 240ms^{-1}

v= u + at

v= 240 + (-5)(20)

v= 140ms^{-1}



b. Maximum speed attained = 240ms^{-1}

c. Retardation = $\frac{v-u}{t}$

$= \frac{0-140}{20}$

= -7ms^{-2}

Average retardation = $\frac{-5+-7}{2}$

= -6ms^{-2}

5. I. tan α =$^{3}/_{4}$

α =tan^{-1}($^{3}/_{4}$)

α = 36.87°

Time of flight = $\frac{2usin\alpha}{g}$

$= \frac{2\,(40 \sin 36.87)}{10}$

$= 4.8s$

II. Range $= \frac{u^2 \sin 2\alpha}{g}$

$= \frac{40^2 \sin 2(36.87)}{10}$

$= 153.6m$

III. Time taken to reach the maximum height $= \frac{u \sin \alpha}{g}$

$= \frac{40 \sin 36.87}{10}$

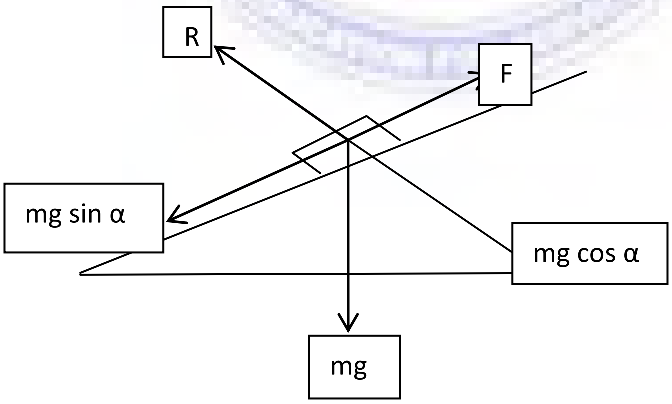
$= 2.4s$

IV. Greatest height $= \frac{u^2 sin^2 \alpha}{2g}$

$= \frac{40^2 sin^2(36.87)}{20}$

$= 28.8m$

6.



APPENDIX D2

ANSWERS FOR FIRST END OF MONTH TEST

1. B 2. A 3. B 4. C 5. B 6. A

7. (a) Heat is energy in transit as a result of a temperature difference. It's unit is joule.

Whiles

Temperature depends on the physical state of a material and is a quantitative description of its hotness or coldness.

(b) Heat can be produced by

i. Rubbing-this is used in the lightening of match.

ii. Burning-this is used in woods

8. Evaporation is the escape of molecules in the form of vapour from the exposed surfaces of solids or liquids at all temperatures. When a liquid boils, bubbles of vapour are formed throughout the liquid. At any given pressure, boiling takes place only at a particular temperature.

9.

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100°C$$

$$= \frac{15 - 3.2}{26.5 - 3.2} \times 100$$

$$= 50.6\ °C$$

$$= 51\ °C$$

10.

While cooling from 60o C to 52o C

Rate of cooling = $\frac{60-52}{5}$ = 1.6°C/minute = $\frac{1.6\ °C}{60}$ per second

∴ Average temperature while cooling = $\frac{60+52}{2}$ =56°C

∴ Average temperature excess = 56 - 32 = 24° C

According to Newton's law of cooling,

Rate of cooling α Temperature excess

∴ Rate of cooling = K × temperature excess

$\frac{1.6}{60}$ =K × 24

Suppose that the cube takes t seconds to cool from 52° C to 44° C

∴ Rate of cooling = $\frac{52-44}{t}$ = $\frac{8}{t}$

Average temperature while cooling = $\frac{52+44}{2}$ = 48°C

∴ Average temperature excess = 48 - 32 = 16° C

According to Newton's law, Rate of cooling = K × (Temperature excess)

$\frac{8}{t}$ = K × 16

Dividing equation (1) by equation (2)

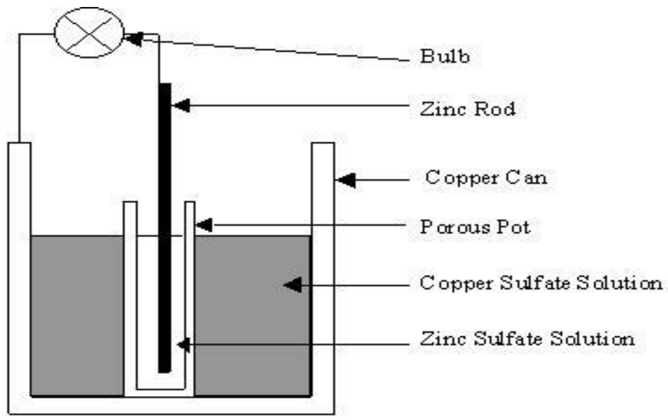
$\frac{1.6}{60} \times \frac{t}{8} = \frac{24}{16}$ = 450s

APPENDIX D3

ANSWERS FOR SECOND END OF MONTH TEST

1. A 2.D 3.D 4.B 5.C 6.B 7. C

8.a



b. the two main defects of the Daniel cell are

1. Polarisation
2. Local action

Polarisation: The working of a cell involves the release of hydrogen gas, which is discharged at the copper plate and forms a layer of bubbles at the positive electrodes. This insulates the plates and is called polarisation. This is reduced by using copper sulphate as the depolariser. The copper plate reacts with the hydrogen to form sulphuric acid.

Local action: This is caused by impurities in the zinc cathode, resulting in the eating away of the zinc. It can be prevented by coating the zinc cathode with mercury. The mercury reacts with the zinc, forming an amalgam.

9. a) Primary cells are cells which produce current as a result of an irreversible chemical change.

b) When the electrodes of the cells are connected to an external conductor, current flows from the positive (carbon) terminal to the negative (zinc) terminal. A chemical reaction set up between the zinc and ammonium chloride which set up an emf that forces the current through the circuit. In the reaction, zinc chloride, hydrogen and ammonia are formed and electrons discharged. The discharged electrons flow through the external conductors through the carbon rod.

10. a) Lemon juice contains citric acid, which is a strong electrolyte. The electrolytes in lemon produce electricity by allowing two metals to react with each other. The acid in the lemon is dissolved into positive and negative ions in its natural water. When rods of copper and zinc are placed in the lemon, a chemical reaction takes place. Within the lemon, electrons flow from the rod of copper to the rod of zinc, turning the zinc into a negative electrode and the copper into a positive electrode

b) The ability of the citric acid to transfer electrons to and from the electrodes.

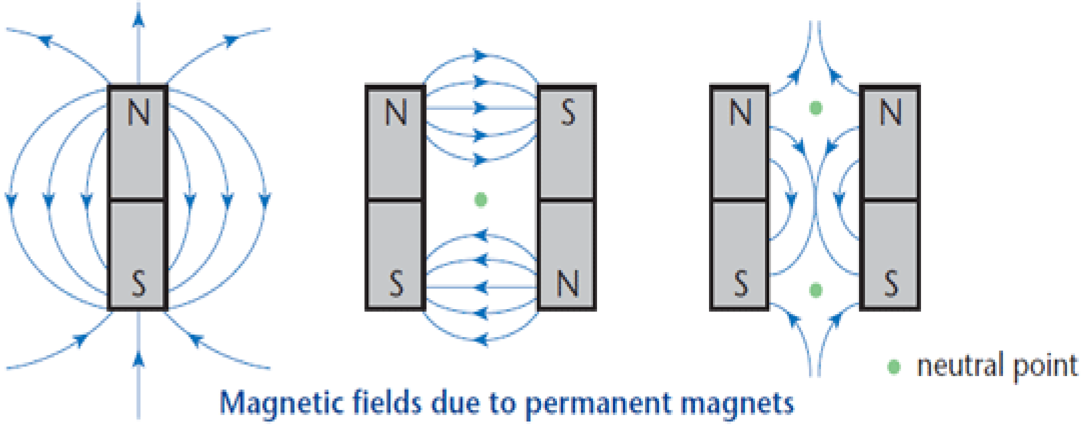
APPENDIX D4

ANSWERS FOR THIRD END OF MONTH TEST

1. C 2. B 3. A 4. C 5. C

6. a) **Magnetic flux Density** is the number of magnetic field lines passing through a given area.

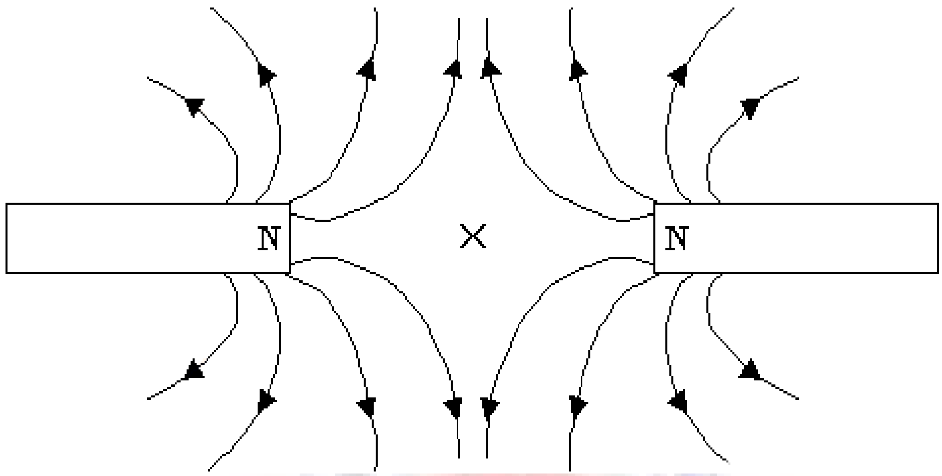
Neutral point is a point where the resultant magnetic flux is zero.



Magnetic fields due to permanent magnets

7. This is because the Earth is a giant magnet, with a north magnetic pole and south magnetic pole like the two ends of a bar magnet. A freely suspended magnetic needle at a point on Earth comes to rest approximately along the geographical north - south direction. This shows that the Earth behaves like a huge magnetic dipole with its magnetic poles near its geographical poles. Since the north pole of the magnetic needle approximately points towards geographic north it is appropriate to call the magnetic pole near geographic north as the magnetic south pole of Earth Sm. Also, the pole near geographical south is the magnetic north pole of the Earth.

8.



9. I. Magnetic lines of force start from the North Pole and end at the South Pole

II. They are continuous through the body of magnet

III. Magnetic lines of force can pass through iron more easily than air.

IV.Two magnetic lines of force can not intersect each other

10. Ferromagnetism is an inherent property of certain materials which makes them magnetic in nature. These materials get attracted towards magnets when they are subjected to the magnetic field of the magnets. Whiles

Ferrites are materials that exhibit ferromagnetic properties below the Curie temperature but they exhibit paramagnetic properties above the Curie temperature.

APPENDIX D5

ANSWERS FOR END OF TERM EXAMS

1.D	2.B	3.A	4.C	5.B	6.D	7.C	8.C	9.B	10.C	11.C	12.A
13.D	14.D	15.B	16.C	17.B	18.C	19.B	20.A	21.B	22.C	23.B	24.A
25.C	26.C	27.B	28.A	29.C	30.A	31.A	32.B	33.D	34.B	35.A	36.D
37.B	38.B	39.C	40.C								

SECTION B

a) Suppose the two rods A and B have the same temperature difference T1 - T2 across their ends and the length of

each rod is l. When the two rods have the same rate of heat conduction, then

$$\frac{K_1A_1(T_1-T_2)}{l} = \frac{K_2A_2(T_1-T_2)}{l}$$

$$K_1A_1=K_2A_2 \text{ or } \frac{A_1}{A_2} = \frac{K_2}{K_1}$$

(i.e) for the same rate of heat conduction, the areas of cross - section of the two rods should be inversely proportional to their coefficients of thermal conductivity.

b)

While cooling from 60o C to 52o C

Rate of cooling = $\frac{60-52}{5}$ = 1.6°C/minute = $\frac{1.6\ °C}{60}$ per second

∴ Average temperature while cooling = $\frac{60+52}{2}$ =56°C

∴ Average temperature excess = 56 - 32 = 24° C

According to Newton's law of cooling,

Rate of cooling α Temperature excess

∴ Rate of cooling = K × temperature excess

$$\frac{1.6}{60} = K \times 24$$

Suppose that the cube takes t seconds to cool from 52^o C to 44^o C

$$\therefore \text{ Rate of cooling} = \frac{52-44}{t} = \frac{8}{t}$$

$$\text{Average temperature while cooling} = \frac{52+44}{2} = 48°C$$

∴ Average temperature excess = 48 - 32 = 16^o C

According to Newton's law, Rate of cooling = K × (Temperature excess)

$$\frac{8}{t} = K \times 16$$

Dividing equation (1) by equation (2)

$$\frac{1.6}{60} \times \frac{t}{8} = \frac{24}{16} = 450s$$

c)

For material to change from solid to liquid it must be heated to its highest possible temperature and when this temperature is reached, further heating will lead to no change in temperature. This heat is known as latent (hidden) heat of fusion.

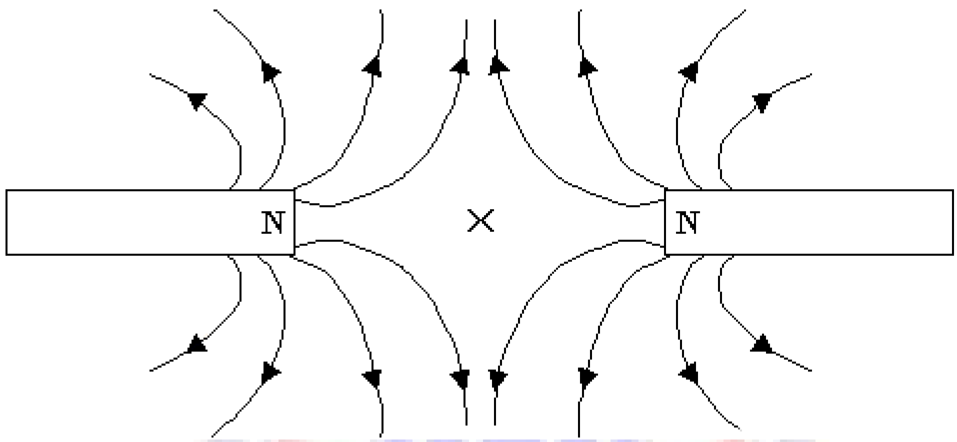
2.

I. Diamagnetic substances are substances that contain atom and molecules with paired electrons. Temperature change has no effect on them

II. Paramagnetic substances are substances that contain atoms or molecules with unpaired electrons. Temperature change has effect on paramagnetic substances. Their magnetic properties decrease with increasing temperature.

III. Ferromagnetic substances are materials that contain naturally occurring magnetic dipoles. Ferromagnetic substances are temperature dependant and they decrease with increasing temperature.

b)



c) Artificial magnets are prepared by imparting the properties of natural magnet to the magnetic substances by rubbing with magnet or by process of induction.

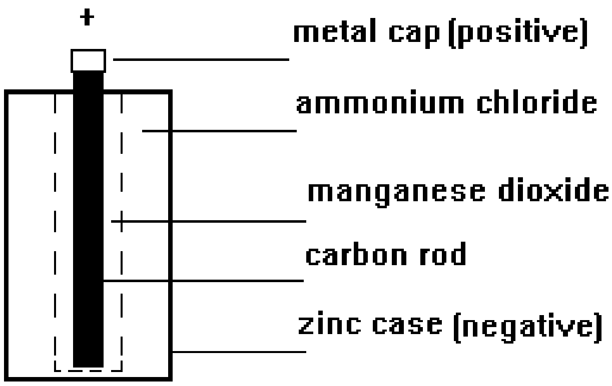
3 a. i

1. Polarisation: The working of a cell involves the release of hydrogen gas, which is discharged at the copper plate and forms a layer of bubbles at the positive electrodes. This insulates the plates and is called polarisation. This is reduced by using copper sulphate as the depolariser. The copper plate reacts with the hydrogen to form sulphuric acid.

2. Local action: This is caused by impurities in the zinc cathode, resulting in the eating away of the zinc. It can be prevented by coating the zinc cathode with mercury. The mercury reacts with the zinc, forming an amalgam

ii. It has low internal resistance and as such gives a large current with little drop on terminal potential difference. It can be recharged.

b.



Dry cell (Leclanche)

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C.This is because an accumulator can maintain a large current for a long time without polarisation and also can be recharged when discharged. Whereas, a primary cell produces current irreversibly and this runs down easily.

d.

I. Positive terminal is carbon

Negative terminal is zinc

Electrolyte is ammonium chloride paste.

II. Positive terminal is lead (iv) oxide electrode

Negative terminal is lead electrode

Electrolyte is dilute tetraoxosulphate (iv) solution.