EFFECTS OF PRACTICAL WORK ON STUDENTS’ ACHIEVEMENTS IN PHYSICS AT SECONDARY SCHOOL LEVEL IN MURANG’A EAST SUB-COUNTY, KENYA

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E83/20087/2012

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APRIL 2016
DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any other University/Institution for consideration. This research thesis has been completed by referenced sources duly acknowledged. Where text, data (including spoken word) graphics, pictures or tables have been borrowed from other sources including the internet, these are specifically accredited and references cited in accordance in line with anti-plagiarism regulations.

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DEDICATION
This work is dedicated to my loving wife Lydiah, my daughters, Catherine, Hellen, Sylvia, Patricia, Sarah and Jacqueline. It is also dedicated to my late parents Salome Wanja and Herman Muchai. My late brother Frank who firmly had set the foundation for this work at the very early stage. To my brother John and my sister Elizabeth thanks for all the encouragement you gave me throughout the study.
ACKNOWLEDGEMENT

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I would also like thank Rahab Wanjiru for her typesetting prowess. She did a good job. She typed every letter and edited every sentence to make this report. May God ever bless you.
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### ABBREVIATIONS AND ACRONYMS

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<th>Description</th>
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<tr>
<td>CDF</td>
<td>Constituency Development Fund</td>
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<tr>
<td>FMCE</td>
<td>Force and Motion Conceptual Evaluation</td>
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<td>FSE</td>
<td>Free Secondary Education</td>
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<td>FTSAS</td>
<td>Form Two Students Attitude Scale</td>
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<tr>
<td>HIV/AIDS</td>
<td>Human Immunodeficiency Virus, Acquired Immunodeficiency Syndrome</td>
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<td>ISLE</td>
<td>Investigative Science Learning Environment</td>
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<td>KCSE</td>
<td>Kenya Certificate of Secondary Education</td>
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<td>KESSP</td>
<td>Kenya Education Sector Support Program</td>
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<td>KICD</td>
<td>Kenya Institute of Curriculum Development</td>
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<td>KNEC</td>
<td>Kenya National Examinations Council</td>
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<td>MBT</td>
<td>Mechanics Baseline Test</td>
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<td>MOEST</td>
<td>Ministry of Education Science and Technology</td>
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<tr>
<td>MSS</td>
<td>Mean Standard Score</td>
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<tr>
<td>NACOSTI</td>
<td>National Commission for Science Technology &amp; Innovation</td>
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<tr>
<td>OFCSA</td>
<td>Observation Checklists for Skills Acquisition</td>
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<tr>
<td>PHET</td>
<td>Physics Education Technology</td>
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<tr>
<td>SAT</td>
<td>Student Achievements Test</td>
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<tr>
<td>SEPU</td>
<td>Science Equipment Production Unit</td>
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<tr>
<td>SMASSE</td>
<td>Strengthening of Mathematics and Sciences in Secondary Education</td>
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<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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ABSTRACT

This study explored the effects of practical work on students’ achievements in Physics at secondary school level in Murang’a East Sub-County. The choice of this study was motivated by the declining number of students taking Physics at KCSE in Murang’a East Sub-County. The situation is dire to the extent that some schools do not even present a single candidate for Physics in KCSE. This is despite the fundamental role Physics as a science subject plays in the contribution of innovations and developments required to achieve vision 2030. This study was designed to investigate the effects of practical work in enhancing students’ achievements in Physics in Secondary schools in Murang’a East Sub-County. Specifically, the study was set to achieve five objectives namely to examine the effects of practical work on students’ performance in Physics; to investigate the effects of practical work on students’ attitudinal change in Physics, to assess the influence of practical work in Physics on students’ acquisition of science process skills; to find out whether practical work in Physics has any influence in the number of students enrolling to take Physics in Form Three and to develop a scheme for evaluating practical work in Physics. The study targeted 9820 students in 31 public secondary schools of Murang’a East Sub-County. The study was a quasi-experimental design. It comprised four mixed secondary schools purposely sampled; two experimental groups and two control groups. The main units of analysis were the 188 Form 2 students of the four purposively sampled mixed Day Secondary Schools. All the four groups were exposed to the pretest. The experimental groups were taught using the practical approach for one term while the control groups were taught using the traditional method. The study used four instruments namely: A pre-test Physics Achievements Test, Physics Attitudinal scale, an Observation Checklist and post-test Physics Achievements test. At the beginning of the term, all the four groups sat for pre-test Physics Achievements test. They completed the Physics Attitude scale. They also sat for the post-test achievements test at the end of the term. An observation checklist for skills Acquisition (OCFSA) was used to assess the science process skills acquired by the students. The data obtained were analyzed using SPSS version 21. Student’s t-test was used to compare the mean of the experimental and control groups. The significance of the results was tested at $\alpha = .05$ significance level. The results of the study showed that Practical Approach resulted in higher students’ achievements in Physics, lead to improved students’ attitude towards Physics and resulted in higher student enrolment in Physics at KCSE. This approach also resulted in improved students’ acquisition of science process skills. Finally, a prototype marking scheme for evaluating practical work in Physics was developed. The study concluded that, practical Instructional Approach towards Physics is an effective teaching method which Physics teachers should be encouraged to use to enhance students’ achievements in the subject. The study recommended adoption of the teaching approach and marking scheme in all schools in Kenya in order to boost students’ achievements, enhance acquisition of science process skills, improve students’ attitude towards the subject and increase the enrolment.
CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Scientific principles are an important tool required by all nations to assist them in developing technological innovation in the present competitive world. For any nation to develop socially, economically and technologically it requires a strong scientific background. There are several challenges facing the world today which include emergence of new drug resistance, effects of genetic experimentation and engineering, ecological impact of modern technology, dangers of nuclear war and explosions and global warming among others (Alsop & Hicks, 2001). These challenges have triggered rapid innovation and technological advancement in fields such as communication and agriculture. Among the sciences, Physics is one of the instrumental subjects that spearhead innovation and technological advancement.

Science education is instrumental to the development of any nation (Kola, 2013). It is reason behind the success in science and technology in the developed world. The launching of sputnik in 1957 by the Russians was only possible because of the position they placed physics education (Olyede, 2013). Physics is one of the subjects in science education. It involves the study of matter, energy and their interactions (Chu & Lin, 2002). It plays a key role in the future progress of mankind. The interest and concerns of physics education form the basis of technology.

Physics generates fundamental knowledge needed for the technological advancement which will in turn spearhead the economic engineering of the world (Zhaoyao, 2012). The concept learnt in physics contributes immensely to the
technological infrastructure needed to make scientific advances and discoveries (Kola, 2013).

Physics plays a major role in health education, economic development, energy and environment. The x-rays, radioisotope nuclear resource imaging, laser electron, microscope, synchrotron radiator among other advances in medicine depend on physics (Kola, 2013). The knowledge of electronics and quantum physics has enabled development of computers technology (Viladya, 2003). Our world is more connected through them and the conduction of business around the world is done almost effortlessly (Olufunke, 2012).

Advances in physics have benefited the transportation industry from building of efficient automobiles, sea vessels, aeroplanes to navigation using the global positioning system (Juan, 2009).

Physics plays an important role in technological advancement. This is because the principles of physics are the ones which are used in the production of such technologies like computers (Jucevicience & Karenauskaita, 2004; Zhaoyao, 2002). Acquisition of physics knowledge and principles helps in various encounter and scientific advancement. The wheel and aeroplane and all other Machinery depends on knowledge of physics, Mobile phones and their attendant spinoff technologies. Physics continues to influence applications in medicine, medical methods including imaging technologies (X- rays, CT- Scanning, ultra-sound, echo techniques, MRI technologies) and diagnostic patient screening techniques (Freeman, 2012) are based on Physics principles. 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.

Despite the importance of Physics in the scientific and technological development, it appears Physics education has been facing various challenges. First, the enrolment in Physics course at all levels is low in many African countries (Amunga et al., 2011a). Many reasons are advanced for this discrepancy which include inadequate lower level preparations, weak mathematics background, and lack of job opportunities outside the teaching profession, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Semela, 2010). Many students consider Physics as difficult, abstract and theoretical (House of Lords, 2006). Many students find the subject boring, unemployable (Hirschfield, 2012) and as a result interest in high school Physics is decreasing. Secondly, the students’ enrolment is low compared to other sciences (Garwin & Ramsier, 2003). In many school curricula little time is allocated for the discipline compared to language and mathematics. In secondary school curriculum in Kenya, Physics is allocated five lessons per week in Form Three and Four whereas English Language and Mathematics are allowed eight and seven lessons per week respectively.

In Kenya, the secondary school education takes a duration of (4) four years. On joining Form One, the student is taught all the subjects in the curriculum. This means that all the three science subjects that is, Physics, Chemistry and Biology are compulsory. This trend continues in the second year in Form Two. It is at the end of Form Two when a student is expected to make a choice of the subjects to pursue in Form Three and Form Four. Therefore the study targets Form Two as it is at this
crucial point that major decisions that affect the feature of the students and the country at large are made.

There has been low enrolment in Physics in Kenya Certificate of Secondary Education (KCSE). This is presented in appendix I. Appendix I shows that the number of candidates enrolled for Physics is low compared to the other science subjects (KNEC, 2009). However, the numbers have been increasing since 2006. This trend is good but still low compared to other science subjects (KNEC, 2010).

The student’s achievements in Physics in KCSE between 2006-2009 are presented in appendix II. The results shows that the highest mean score was in 2007 (M = 27.54, S.D = 37.00) and the lowest mean score was recorded in 2009 (M = 20.87, S.D = 19.87). It implies that students have never managed to get a mean score of 30 percent. This shows that the achievement is low. It also shows that there are underlying issues behind these results. This calls for the need for the current study.

Low enrolment and achievements have also been recorded in Murang’a East Sub-County. The results are presented in appendix III. The number of candidates enrolled for Physics as compared to the other science subject is very low (Murang’a East Sub-County, QASO, 2012). In the year 2009, the Physics candidature was only 30.99% compared to that of Chemistry and Biology which was 97.77% and 88.67% respectively of the total candidature who sat for the KCSE in that year.

Muhoro (2009) carried out a study to investigate the factors contributing to low enrolments in Physics at secondary school level in Central Division, Garissa District in Kenya. He found out that students’ attitude towards the subject could be one of the causes. The current study investigated the effects of practical approach as an
instructional method on students’ attitude toward Physics. It further investigated the effects of the approach on student’s enrolment in Physics at KCSE. Appendix III shows that only 651 candidates registered for Physics in 2012 in Murang’a East Sub-County which comprised only 39.07% of the total candidature. In the same Sub-County, 1611 (96.6%) candidates had registered for Chemistry while 1200 (72.02%) candidates had registered for biology. This shows that the enrolment of Physics at KCSE in the sub-County is low. This trend is more severe in the day schools where in some schools there are no candidates for Physics (Appendix III). The problem of low enrollment and poor achievements is particularly noticeable amongst the girls in Kenyan secondary schools (Wasanga, 2009).

According to Twoli (1986), major factors which attributes to differences in achievements in science between boys and girls in National examinations include unequal distribution of resources among schools of different types and motivational differences brought about by different cultural backgrounds. Thus, provided the similar environments, girls may perform just as well as boys. The trend of opting out of Physics which influences technology is worrying given Kenya’s emphasis on the achievements of visions 2030 (Amunga & Musera, 2011b) it should be expected that the demand for Physics should be growing due to its strong influence on technology programs at university and other tertiary institutions of learning.

The low enrollment in upper secondary in Physics has been linked to a number of factors. This includes availability of competent and well-motivated teachers of Physics, availability of laboratory facilities and the accompanying limited exposure to practical instruction at junior secondary level (Daramola, 1987). Kizito, (1986)
showed that lack of appropriate apparatus and inability of teachers to improvise hinder effective teaching of science. This has meant that teacher resort to theoretical teaching neglecting the practical approach. This has led the students to have negative attitude towards the subject hence disliking it and therefore low enrolment. The science teachers are mainly trained in theoretical content aspects. Teachers training in handling Physics practical lessons have been ineffective in many developing countries including Kenya (Masingila & Gathumbi, 2012).

Training in conducting school type science experiments is completely ignored in many university teachers training curricula (Masingila & Gathumbi, 2012). Many if not all the Kenyan university trained Bachelor of Education (science) graduates lack the skills of handling high school type practical work. There are no teaching laboratories set aside for this exercise in the various Kenyan universities that train teachers (Masingila & Gathumbi, 2012). The situation has improved though with many school establishing science rooms or laboratories through KESSP programs and through CDF. Being a science subject, effectiveness of teaching Physics depends on the practical activities that teachers and students undertake in the process of learning the subject (Oyoo, 2004).

Practical work may be considered as engaging the learner in observing or manipulating real or virtual objects and materials (Millar, 2004). Appropriate practical work enhances learners experience, understanding, skills and enjoyment of science. Practical work enables the students to think and act in a scientific manner. The scientific method is thus emphasized. Practical work induces scientific attitudes, develops problem solving skills and improves conceptual understanding
Practical work in Physics helps to develop familiarity with apparatus, instruments and equipment. Manipulative skills are acquired by the learners. Expertise is developed for reading all manner of scales. The observations made and results obtained are used to gain understanding of Physics concepts.

Science process skills, necessary for the world of work are systematically developed (Manjit et al., 2003, Twoli, 2006). Through the practicals in Physics, the abstract ideas can be concretized and it also motivation and interest for learning Physics (Osborne, 2002). Students tend to learn better in activity based courses where they can manipulate equipment and apparatus to gain insight in the content. Millar (2004) has suggested that practical work should be viewed as the mechanism by which materials and equipment are carefully and critically brought together to persuade the Physics learner about the veracity and validity of the scientific world view. If practiced in the right manner from the early secondary school level, critical thinking skills can be attained from practical work in Physics. Practical work puts the students at the center of learning where they can participate in, rather be told about Physics. In this way the desire and eagerness to know more about what the subject can offer is developed. The study was conducted in Murang’a East sub-County due to a number of reasons. First, as shown in Appendix III, there is a low student’s enrolment in Physics in the Sub-County. The number of candidates enrolled for Physics as compared to the other science subjects is low. For example, in 2009, the Physics candidature was only 30.99% compared to that of Chemistry and Biology which was 97.77% and 88.67% respectively. Equally, the students’ achievement at KCSE is also low in the County. According to the 2015 KCSE analysis results,
majority, 508 students (78%) of the students who sat for Physics scored below D (County Director of Education Office-Murang’a). These twin issues of low enrolment and low students’ achievements in Physics in the Sub-County informed the design of the study.

1.2 Statement of the Problem

Physics is a compulsory subject for all students at Form One and Form Two in Kenyan Secondary schools. Many students choose to drop Physics as evidenced by the low student enrolment in KCSE (Wasanga, 2009). In addition, there is poor students’ achievement in KCSE. Several studies have been done to address the problem. Several interventions have been put in place to address the identified challenges. They include in-servicing of Physics teachers through SMASSE, provision of teaching resources through KESSP, campaigns on the importance of Physics (Nderitu, 2009). Despite these multi-faceted interventions, there are still low enrolments in the Murang’a East sub-county and the students’ achievement in Physics in KCSE is still low. This implies that there could be other factors not yet explored. The study contends that practical work if used as a pedagogical strategy could form part of the solution. Therefore the study was designed to investigate the effects of practical work on secondary school students’ achievements in Physics in Murang’a East Sub-County. The specific achievements which were focused in this study were: (1) Performance, (2) Attitudinal change, (3) Acquisition of scientific process skills and (4) Enrolment in physics at Form Three.
1.2.1 Purpose of the Study

The study was set to investigate the effects of practical work in Physics on students’ achievements in Physics in Secondary schools of Murang’a East sub-County.

1.3 Objectives of the Study

The study was guided by the following objectives:

1. To investigate the effect of practical work in Physics on students’ achievements in Physics
2. To develop a scheme for evaluating practical work in secondary school Physics.

1.4 Hypotheses

This study was guided by the following null hypotheses:

H₀₁: There is no significant difference in student performance in Physics for Form Two students taught Physics through practical work and those not taught through practical work.

H₀₂: There is no significant difference in attitudinal change towards Physics for Form Two students taught Physics through practical work and those not taught through practical work.

H₀₃: There is no significant difference in acquisition of science process skills for Form Two students taught Physics through practical work and those not taught through practical work.
H₀₄: There is no significant difference in enrolment in Physics for Form Two students taught Physics through Physics practical work and those not taught through practical work at Form Three.

1.5 Significance of the Study

The study found out students’ involvement in meaningful practical work contributes to improved achievements in Physics. This information may be helpful to Physics teachers who embrace the practical approach in their teaching. Teachers training institutions may be in a position to change their training approaches and emphasize practical work. Curriculum developers will have to change their approach in designing the curriculum and incorporate more practical aspects in the curriculum. The result may be useful to Kenya National Examination Council when setting Physics examination so that the examination can emphasize evaluation of science process skills rather than the product. The inspectors of schools may find the findings useful. They may need to change their approach to inspection so that they can inspect the practical and skill acquisition processes.

1.6 Delimitation and Limitations

1.6.1 Delimitations of the Study

The study was undertaken in four public day secondary schools in Murang’a East Sub-county. The four schools were randomly selected from the 24 day schools. These day schools had low students’ performance in Physics at KCSE. In addition, they had low enrolment in KCSE. The study excluded one county, one national, two private and three district schools because they had high Physics M.S.S in KCSE and high enrolments in Physics. The study involved only one class among the two
streams of Form Two students in the selected four secondary schools in their third term of the study. This is because it is at form Two that students in secondary schools make subjects choices. The study was also limited to one term of fourteen (14) weeks. The study was limited to four (4) topics as stipulated in the syllabus. The study had no right of choosing which topics to teach except those stipulated in the syllabus and schemes of work.

Thus the findings are likely to reflect the situation in the day schools but cannot be generalized to other schools in the county or other counties in the country.

1.6.2 Limitation of the Study

The study involved only the Form Two classes. It was limited to syllabus as stipulated by KICD. The researcher did not have the freedom to choose what to be taught but had to adhere to the schemes of work provided by the school. The number of lessons per week had to be limited to what is provided for.

1.7 Assumptions of the Study

In undertaking this study, several assumptions are taken into consideration.

a) The schools selected had the necessary equipment to perform the practical work.

b) The teachers administering the treatment are all qualified in Physics Education.

c) All the students in the sample had covered the work of Form One syllabus and Form Two in Term One and Two.
1.8 Theoretical Framework

The theoretical framework for this study was based on Jean Piaget theory of cognitive development and Jerome Bruner theory of Cognitive Development. Jean Piaget (1896-1980) studied the development of children’s understanding and particularly the role of maturation in children’s increasing capacity to understand their world. According to him, children cannot undertake certain tasks until they are psychologically mature enough to do so. His theory is called cognitive theory and is central to the school of cognitive theory called cognitive constructivism.

There are several key principles of Piaget theory. First is adaptation. According to him, a child adapts to the world through assimilation and accommodation. He referred to the process by which a person takes material into their mind from the environment as assimilation. This is also accompanied by accommodation; the difference made into one’s mind by the process of assimilation. The other key idea of the theory is classification-ability to group objects together on the basis of common features. A fourth tenet of the theory is class inclusion-the understanding that some classes or sets of objects are also sub-sets of a larger class. His fifth key idea was the realization that objects stay the same even when they are changed about or made to look different, which he called conservation. His other key tenet was operation- the process of working something out in one’s head. According to him, young children have to try out things in the real world like count on fingers while older one can use their heads.

Finally, he talked of a scheme or scheme which is a representation in the mind a set of perceptions, ideas, and or actions which go together. Piaget postulated that there
are 4 stages of cognitive development. These include the sensori-motor (birth-2 years), pre-operational (2-7 years), concrete operational (7-11 years) and formal operational (11 years and above). The sensori-motor stage is characterized by the child differentiates self from objects and achieves object permanency. In the pre-operational stage, the child learns language and to represent objects by images and words. The concrete operational stage is characterized by the child being able to think logically about objects and events. Finally, in the formal operational stage, the child can think logically about abstract propositions and test hypothesis systematically.

In this theory, Piaget argue, that there is a continuous reorganization of the child’s mental processes as he grows and interacts with the environment. Children learn by manipulating the environment they build information in their minds which he called schemas. These schemas kept improving and growing as the child grows from one stage to the next stage. The importance of Piaget’s theory to this study is that a child learning by doing things on his own. It is not easy to learn from the teacher just giving the child information. According to him, a child’s meaningful learning is through manipulation of the environment. Children are able to construct their own knowledge by manipulating the objects in the environment.

This theory of cognitive development was used to anchor the study because practical work in Physics involves manipulation of the apparatus in order to understand concepts. The role of the teacher is that of a facilitator but the child and his peers systematically construct their own knowledge through manipulation of the apparatus in Physics practicals.
The second theory on which the study is anchored on is the Cognitive development theory by Jerome Bruner (1962). According to him, the goal of education should be intellectual development and not memorization of facts. He insisted that learning should entail the acquisition of the process of knowledge but not mere memorization of facts. Instruction should therefore teach the learner how to participate in the process that makes possible the establishment of knowledge. It should not be a matter of getting the learner to commit the results to mind. The aim of teaching a discipline is to get learners to take part in the process of knowledge. According to him, acquiring knowledge is a process rather than product.

Bruner advocated organizing concepts and learning by discovery. He believed that learners can be able to construct knowledge by interacting with the world around them. He identified three stages of cognitive development, the enactive, iconic and symbolic representations. Enactive, which is the representation of knowledge through actions while iconic, which is the visual summarization of images. The last one is the symbolic representation, which is the use of words and other symbols to describe experiences.

The enactive stage appears first. This stage involves the encoding and storage of information. There is a direct manipulation of objects without any internal representation of the objects. For example, a baby shakes a rattle and hears a noise. The baby has directly manipulated the rattle and the outcome was a pleasurable sound. In future, the baby may shake his hand, even if there is no rattle, expecting his hand to produce the rattling sounds. The baby does not have an internal
representation of the rattle and, therefore, does not understand that it needs the rattle in order to produce the sound.

The iconic stage appears from one to six years old. This stage involves an internal representation of external objects visually in the form of a mental image or icon. For example, a child drawing an image of a tree or thinking of an image of a tree would be representative of this stage.

The symbolic stage, from seven years and up, is when information is stored in the form of a code or symbol such as language. Each symbol has a fixed relation to something it represents. For example, the word 'dog' is a symbolic representation for a single class of animal. Symbols, unlike mental images or memorized actions, can be classified and organized. In this stage, most information is stored as words, mathematical symbols, or in other symbol systems.

Bruner believed that all learning occurs through the above stages. He believed that learning should begin with direct manipulation of objects. It should be followed by construction of visual representations, such as a drawing a shape or a diagram. Finally, a learner understands the symbols associated with what they represent. The theory is applicable in this study because it advocated learning through a process. The process of acquiring skills in physics is a process. The current study advocated that the science process skills should be evaluated because it is through the processes that the learner acquires knowledge but not the end product- the results. According to Brunner the process of knowledge acquisition is more important than the product.
1.9 Conceptual Framework

The study conceptualized the teaching approaches in Physics as the independent variables. The students’ achievements in Physics were considered as the main dependent variable. These variables are interrelated as depicted in Figure 1.

**Figure 1: Conceptual Frame Work**

Figure 1 shows that the independent variables of the study were the two teaching approaches; practical approaches and the conventional approach. The students’ achievement in Physics was conceptualized to be the dependent variable. The students' achievements in Physics were measured using four indicators; science skills acquisition (observation, recording, measurement, communication, classification, classification,
hypothesizing) positive attitude towards Physics, improved achievements in examination and improved enrolment in Physics in KCSE.

The independent variable however can be intervened by availability of resources; both human and capital and schools administration. Well equipped laboratories for carrying the practicals in Physics, schools enrolment policy may also moderate the dependent variable.

1.10 Operational Definitions Terms

Some of the operational terms used in the research study are:-

**Attitude Change:** Change in perception towards the subject as a result of using practical work approach in teaching Physics.

**Conventional Method:** Method of teaching Physics by using lecture method with only a few teacher demonstrations.

**Practical Work:** It is work in which students interact with materials or with secondary sources of data to observe and understand the material world.

**Science Process Skills Acquisition:** This is acquisition of skills like observation skills, drawing skills and reporting and interpretative skills achievements in Physics.
1.11 Chapter Summary

In this chapter the background to the study was laid down. The main purpose, objectives and research hypotheses were also outlined. It also explained the significance, assumptions, limitations and delimitations of the study. The theory upon which the study is anchored is also explained. Operational definition of key terms was done. Finally, conceptualization of the variables of the study was also done. The basis of the study was that practical approach as an instructional method could influence students’ achievements in Physics at KCSE.
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

A literature review is an account of work which has been published on a topic by accredited scholars and researchers (Kombe & Tromp, 2006). It critically looks at the existing research that is significant to the work that the researcher will be carrying out. This chapter reviews the importance of science in societal development, importance of Physics to the society and students’ attitude towards Physics. The chapter will also review the different approaches of teaching Physics and the importance of practical work in the teaching of Physics.

2.2 Importance of Science to Society

The importance of science to society cannot be over emphasized. One of the reasons for studying science is that it enhances one’s enjoyment and appreciation of the natural world. More profoundly, science offers an understanding of ourselves, of the universe, and of our own place in it, which must be ranked as one of human kind’s greatest achievements. Consequently, there are economic benefits, both to individuals who study science, and to countries whose citizens include many individuals with an extensive knowledge of science. Further, many of the problems currently confronting the society, such as the looming energy and population crises, global warming, HIV & Aids and ethical issues involving biotechnology require knowledge of science if they are to be dealt with rationally (Vander wolf et al., 2005).
It is important for any scientist to understand the principles of natural schema and be able to give an explanation to these phenomena. In the present world, it is important to note that to achieve any goals in socio-economics, one need to interpret all things scientifically. Therefore, the essence of the modern world depends on scientific technology (Juan, 2009). For example, physical sciences have been, are and will continue to be a major conceptual pillars and application for certain professions such as engineers and technologists, as it helps in the development of their thinking and in the structure of their minds (Harley, 2010).

2.2.1 Students’ Attitude towards Science Subjects

Students’ attitudes towards natural science constitute an important area in science education. Few students are interested in natural science and they do not choose the corresponding science disciplines in post-secondary education. A survey on high school students’ interests and attitudes towards science topics according to their genders, grades, and parents’ educational levels was undertaken by Akarsu & Afsin (2013). The results of the study revealed that some degree of relationship exists between students’ attitudes towards science and corresponding variables: science interests, genders, grades, and parents’ educational levels. Further, the study revealed participants’ interests in various science branches and their relationships with factors such as genders, grades, and parents’ educational levels and occupations. It was also found that students were most interested in general science concepts with a popularity rating of around 50%. This might indicate that students like science when they are first introduced with general science concepts. A possible
explanation for this could be related to how they are introduced and what techniques teachers utilize for them.

2.3 Importance of Physics to the Society

The broad aim of Physics is to understand and explain various physical phenomena occurring in nature/laboratory through observation, experimentation and theoretical formulation. Well known examples of physical processes are the motion of planets around the sun, evaporation of water, sound emission from a tuning fork, refraction of light, attraction of iron by magnets, discharge of an electrical capacitor, and decay of the pi meson (Agrawal & Menon, 2010). Thus, meaningful learning of Physics is acquired through proper planning of Physics syllabuses and their relationship to environmental issues. It is important that at secondary school, the aim of Physics should be acquisition of process skills. These skills help the students apply Physics knowledge to solve every-day problems. In addition, these skills aid in the acquisition of the Physics concepts and apply them in their daily life (Zdenek & Hana, 2008).

Furthermore, Physics strives towards an understanding of the material universe. To gain this understanding, physicists systematically question nature through experiments. These experiments are designed to challenge existing hypotheses and provide clues to more powerful theories. However, experiments are not only essential in expanding our knowledge of our universe, but play a key role in the teaching of Physics (Chris & Vollmer, 2006).
2.4 Challenges faced in the Teaching and Learning of Physics as a Science Subject

The challenges faced by Physics as a subject include teachers’ training and conceptualization of the subject, students’ understanding of the subject, physical resources such as laboratories, teaching aids and text books. Research findings suggest that traditional lecture instruction is ineffective in dealing with students’ misconceptions. Traditional lecture instruction does not consider the view of students. This technique is limited in helping a learner develop skills (Tarekegn, 2009). The practical approach on the other hand engages the student productively and leads to relational understanding. The proposed study contends that if practical work instructional approach is used perhaps improved students’ achievements in the subject may occur. In addition, the enrolment is likely to increase. It is on this basis that the proposed study is designed to investigate the effects of Physics practical work on students’ achievements in Physics.

According to Chiu (2000), it has been observed that students taking physics at all levels find it difficult to internalize physics concepts which do not agree with what they had already internalized (Refik & Bahattin, 2008). Furthermore to capture and retain interest in the subject is one of the many difficulties faced by the teachers. A number of research conducted have shown that teaching of physics faces the same problems in the whole world. This is credence by Mac Dermott (1998), who showed that students from different cultural background and social classes have different understanding of physics concepts. However many young people have similar understanding of physics concepts.
A study conducted by Juan (2009) on totalizing of didactic teaching-learning process in physics. The study found out that the teaching and learning physics faces some challenges since its teaching has been largely confined in the classroom. He also found out that the teaching appealed more to the cognitive domain and little on the affective-emotional domain. Teaching and learning physics was individualized. Another finding was that learning was not focused on changing the individual to change the environment but learning was focused on making the individual to fit in the environment. Thus, due to the foregoing it is important to change the approaches of teaching so as to improve it and be meaningful. Also, it is worth noting that there is a break down between the practicals and theory taught. The practicals are taught as a different entity from the theory and this does not reinforce concept acquisition. Practicals should be integral part of teaching and theory should be derived from the practical (Juan, 2009). This informed the designing of the current study.

Another challenge facing the Physics as a subject is inadequate content knowledge by the teachers of Physics. Fadaei (2012b) carried a research to find out the teachers level of knowledge acquisition. It was based on Force and Motion Conceptual Evaluation (FMCE) for teachers understanding of mechanics concepts. It was administered to a large group of teachers in teacher training courses. The study found out most of the Physics teachers did not completely understand kinematics and dynamics concepts.

In addition, Assessments using the FMCE indicate that teacher understanding of dynamics concepts will be improved when some learning strategies are planned.
Therefore, 1) Self-evaluating for teachers to know their abilities and motivating them to be more active in teaching. 2) Recognizing the necessity and planning for teacher training projects have to be emphasized. María et al., (2012) proposed a new approach to teaching Physics having considered a problem within the teaching of Physics, in two aspects: The first, the didactic part, which concerns the professor, since Physics courses, generally, are imparted without giving the student an active role and with knowledge and concepts unlinked of his/her environment, making the teaching and learning of this subject lose its essence and significance. The second, the discipline part, has to do with the student; since it is observed recurrently that even with the education, the student does not use precisely the concepts of a studied theme when explaining or arguing a Physic problem or situation. Particularly within the Heat topic, although there is a daily generalized interaction of people with thermal phenomena.

Evaluation is a key stage in all teaching-learning processes, but it usually demands significant efforts of preparation from students and teachers, not to mention that it is very time-consuming. The traditional model of evaluation prescribes that students must sit periodically to demonstrate that they can recite blocks of knowledge, and solve exercises and problems which usually resemble or refers to the same set of study cases presented in lectures, in the laboratory, or the textbooks. Thus conceived, evaluation is indeed lacking, particularly in Physics teaching.

Therefore, there is a need to develop effective physic teaching evaluation methods which puts into consideration the following factors. This includes exploiting the examinations as opportunities for further learning and as a way of acquiring new
knowledge, or learning new analytical techniques. It also means seeing examinations as an opportunity for the application of standard powerful tools which students learned in their previous mathematics and Physics courses (Celso, 2009).

### 2.5 Methods of Teaching Physics

There are various ways in which sciences and Physics in particular can be taught and these methods have continuously evolved over time. New development in cognitive science especially the works of Piaget, Bruner, Gagne, Bloom and others have spearheaded the attack on rote learning which dominated the traditional science. They have called for active participation of the learner in the acquisition of knowledge. This calls for process-based science learning (Bybee, 1981; Wellington, 1989).

The goal of science education is to produce students who can be able to deal with daily environmental, social economic issues which they come across in their daily lives. Zdenek & Hana (2008) argue that it is important to note that any changes in physics curriculums should be taken into account that students will be more interested in solving issues which are within their environment.

Physics education research shows that alternative approaches result in a wider range of students making much greater changes in their understanding of the phenomena than the conventional method (Dykstra, 2012). Yet, findings have not resulted in major changes in Physics teaching (Fadaei, 2012). Then practical approach in the teaching of physics enable learner to acquire physics concept through a process rather than memorization. This method is learner-centered and makes the learner to process the concept in a systematic manner. Teachers create an environment where
students construct their own understanding of the subject. The quality of the construction depends crucially on the conceptual tools available to the students and facilitation by the teacher. Effective teaching requires complex skills which take years to develop. Technical knowledge about teaching and learning is as essential as subject content knowledge (Fadaei, 2012).

Moreover, when Physics contents are presented following an active Physics learning methodology (Investigative Science Learning Environment, ISLE), in which students observe, explain and test their explanatory models through predictions and posterior observations positive results are obtained (Méndez Coca, & Slisko, 2013). Garuma & Tesfaye (2012) conducted a study to investigate and contrast the relative effectiveness of guided discovery, demonstration and traditional lecture method of teaching on students’ achievements in rotational motion among Grade 11 students from three selected preparatory schools in Ilu Aba Bora Zone located in southwestern part of Ethiopia. The study found (1) guided discovery is more effective in improving students’ achievements followed by demonstration method while the traditional method is the least effective. (2) The students’ achievements have a strong relationship with their background achievements levels (high-, medium-, and low-achiever) besides the effect of the instructional methods. Therefore, it recommended that Physics teachers in the zone should implement guided discovery with sufficient guidance to help students create, integrate, and generalize knowledge through constructivist problem solving by providing them with materials available in Physics lab or locally prepared teaching materials.
Tesfaye & Getinet (2012) carried out an experimental study in Nigeria to investigate on the effects of instructional interventions on students’ learning gains. The study aimed at investigating the effect of question-answer approach on gain in students’ understanding of the basic concepts in Mechanics. The result of the research indicated that students exposed to the question–answer approach with group discussion as a teaching intervention performed better than students taught by teacher lecture on Mechanics Baseline Test (MBT). The current study was designed to investigate the effects of practical work in Physics on students’ achievements in Physics.

On the basis of their findings, Gamze et al., (2008) recommended that teachers of physics need to use problem solving method so as to help the students develop the same. This is because from the research they conducted it was evidential that problem solving method and practicals involves the students in the learning process and therefore be good problem solvers. The practical approach is one approach which equips students with skills to enable them solve the everyday problems (Huffman, 1997). The practical approach to teaching physics can be put into two groups: (1) Classroom experiments where students are allowed to perform experiments on their own in the laboratory with the teacher acting as a guide and (2) Demonstration- this involves the teacher demonstrating when the students observed and asked questions Gamze et al., 2008).

Silay (2010) conducted a study to examine the effects of teaching problem solving strategies on the students’ achievements in Physics, students’ attitude, and achievements motivation. Experimental procedures were conducted on the tenth
grade students in Turkey. During the study, problem solving strategies were applied to the experimental group by the cooperative learning method and to the control group by conventional teaching. The averages of the experimental group’s achievements, motivation and attitude were found to be higher than that of the control group. It was concluded that problem solving strategies were more effective in cooperative learning than conventional teaching. The study concluded that the reasons for the increase in the experimental group’s attitude score were: systematic application of the problem solving strategies, information exchange during the teamwork, paying attention to applied methods, excitement, and supporting and helping each other. Therefore, it can be concluded that the teaching of problem solving strategies affects the attitudes of the students toward problem solving. Thus, evidentially the ability of the students to solve problems should be the main goal of testing and hence, students should try to solve as many problems as possible (Gamze et al., 2008).

When practicals are used by the teacher when teaching, these will make the understanding of the concepts clear. A study was conducted to investigate whether there was any differences can student’s acquisition of physics knowledge using the practical problem solving approach (Refik & Bahattin, 2008). Furthermore, practicals are learning tools which help students to concretize concepts and compare the theoretical, practical and real words. These practicals also arouse interest in students. Practical help the teacher and learner to bring the real world into the laboratory and help the learner compare the two and thus have better understanding of the principles (Chiu & Lin, 2002). A lot of research had been conducted to find
ways and means of improving the teaching and learning of physics and it has been established that science process skills help the student to understand concepts and other global issues (Juan, 2009.)

2.6 Practical Approach in the Teaching of Physics

Physics is a science based on experiences and whose facts are found empirically (Michael & Möllmann, 2012). The most suitable in relation to teaching and education is concerned is the successful deployment of the tools you have, because the tools themselves cannot accomplish the work of education, i.e., the laboratory more accurate, more perfect simulation, the more consistent mathematical development or historical and epistemological development can foster more accurate or direct the student to learn lines, and even more, knowing a student's level of technology, which is the product of a process which culminated in the development of his professional practice (Harley, 2010).

Learning which involve the students going to the laboratory and getting involved in manipulating and observing things in a systematic way can be called practical works. Wherever this exercise takes place it does not matter because it can be in the field to observe animals and plants or it can be an educational trip (Millar, 2004). The increasingly availability of information technologies in schools allow students to learn about contemporary scientific research and engage in inquiry at the frontiers of scientific knowledge. In sum, laboratory investigation holds significant promise for being able to support conceptual and epistemological learning when facilitating conditions are put in place for students (Bell, 2005).
For more than a century, laboratory experiences have been purported to promote central science education goals including the enhancement of students’ understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific ‘habits of mind’; understanding of how science and scientists work; interest and motivation (Hofstein & Mamlok-Naaman, 2007). Thus, the laboratory has been given a central and distinctive role in science education, and science educators have suggested that rich benefits in learning accrue from using Laboratory activities (Hofstein & Lunetta, 2004). Inquiry-type laboratories have the potential to develop students' abilities and skills such as posing scientifically oriented questions, forming hypotheses, designing and conducting scientific investigations, formulating and revising scientific explanations, and communicating and defending scientific arguments (Hofstein & Mamlok-Naaman, 2007).

Science teaching and learning cannot be called science without practicals. Practicals help the students understand scientific concepts and acquire science process skills. Practicals can be of two types of class practicals with students free to use the instruments available. These are open-ended and help the students develop scientific mind. The other is demonstration by the teacher (Millar, (2004).

In teaching Physics, experimental work is an integral component in giving the starting point of knowledge formation and conceptualization. Koponen & Mantyla (2006) propose an educationally oriented reconstruction, which is based on the idea that in epistemology of experiments, the inductive-like generative justification of knowledge is central. A generative view makes it possible to retain those aspects of
experiments which make them purposeful for learning and can give a starting point for students’ own construction of knowledge, that it, the generative view makes it possible to retain those aspects of experiments, which make them purposeful for learning by giving a starting point for students’ own construction of knowledge during the learning process. The reconstruction also helps to conceive the experiments with their correct historical role and helps to bring back the generative use of experiments in teaching, which, after all, has never vanished from the practice of Physics.

Experiments are essential in any kind of Physics teaching especially low cost hands-on experiments, which have many advantages for Physics teaching, in particular concerning motivation of students. Hence, low cost experiments have an enormous usefulness in the teaching of Physics (Michael, V., & Möllmann, K., 2012). Furthermore, it is suggested that a recipe for calculating errors of observations in a practical class is given along with the classification and importance of the same. It is hoped that this much background will be sufficient for motivating students to start Physics practical in the laboratory even if the prior theory of the experiment or the distribution theory of errors has not been taught beforehand (Agrawal & Menon, 2010). The primary objective of performing a Physics experiment is to gain procedural as well as conceptual understanding. Some of the researches reported in Physics Education emphasize the importance of introducing innovations in Physics experiments so as to improve clarity as well as the depth of learning experiences. The impact of seven experiments designed in different branches of Physics and systematically tried on college students was analyzed. There was observed a
significant enhancement in the conceptual understanding of the students after exposure to the treatment (Umapati et al., 2012).

Research has shown that the effect of demonstration makes little significant contribution to general and conceptual understanding of the concepts of Physics in cases when students make hypotheses and discuss them, when they create experiments, verify their hypothesis and make conclusions (Svedružić, 2008). To prepare students for further studies they need to think critically and apply knowledge acquired meaningfully Zdenek & Hana, (2008). However, it has been shown that experiments allow students to observe phenomena, test hypotheses, and apply their understanding of the physical world are the most effective. Perhaps of equal importance, experiments have the power to motivate (Chris & Michael, 2006). This is given credence by a study conducted by Irma & Daniel (2012). In that study, they found that it was possible to change the ideas about the magnetic field concept of high school students through experiments making and collaborative work. They suggested that the methodology they used for working with the magnetic field concept could be used for the whole high school Physics course to find if it produces similar results, that is, in order to help students in their conceptual comprehension of physical phenomena. Studies suggest that in conducting laboratory "investigations", students are able to perform numerical measurements and related computer estimations of physical quantities. Further, through intensive and active discussions and debates, the students interpret new facts and data to make them meaningful for themselves. This leads to "discovery" of the fundamental laws or physical regularities (Oidov et al., 2012).
Based on the foregoing, it can be concluded that practical work enhances relational understanding of Physics concepts. The proposed study contends that perhaps this enhanced understanding can lead to students’ improvement in Physics achievements and have positive effects on retention. However, the reality on the ground is that most experiments are sterile which are also accompanied with un-illuminating exercises whose purpose is often lost on the learners. In many countries, practical work is ill conceived, confused and unproductive (Hodson, 1991). Whatever is undertaken in the laboratory in the name of practicals is not related to science at all. There is usually limited planning and formulation of hypotheses, mostly done by the teachers. In many cases the experiments are derived from mostly irrelevant cultural settings with the attendant equipment disasters. The students follow a fixed program of experimental manipulations and observations set by the teacher, cookbook style.

This research acknowledges the great role that well planned and delivered practical work in Physics can play in influencing students learning Physics in the Kenyan secondary school. For this to happen, practical work has to form a central part of classroom learning of Physics. Deliberate effort have to be made to attract and retain students in the Physics class by appealing to the curiosity raising element and discovery component of practical work in the subject.

Meaningful practical work is embedded in a discussion of ideas that makes it necessary to check observations and findings against experience and theory. Teachers hold the key to this interchange of ideas. Studies show that secondary school science teachers' education correlates positively with their learners' achievements in matriculation examinations. The theoretical content and
pedagogical content knowledge of the teacher, the ways in which the teacher delivers instruction, and the teacher's attitudes toward science have been shown to have an impact on student learning and achievements (Ware, 1992). This is especially so in the laboratory where the essence of the practical instruction is not immediately abundantly clear to the learners. Drawing meaning out of practical and experimental work requires guided higher level abstraction. Learners can benefit from an inspirational and knowledgeable teacher. All of these factors are related to the teacher's own education, both as a teacher and as a former school pupil. Practical work in secondary school Physics takes the form of laboratory experiments, demonstrations, fieldwork and excursions. Teacher innovativeness and creativity could also introduce novel modes of practical investigations.

In Kenya these innovations include: Physics micro-kits, specifically prepared Science Equipment Production Unit (SEPU) kits, as well as crude improvisations (Ndirangu et al., 2003). Of late, efforts are being made to utilize virtual laboratory that rely on the interplay of the computer and the internet (Scheckler, 2003). Clearly, every effort should be made to create interest in the students to study Physics. Whereas the above efforts can be lauded, this study will concentrate on exploring the role traditional laboratory experiments could play in developing interest in learning Physics amongst form two students. This research will investigate how such an interest may be ignited in randomly selected secondary school in Murang’a county of Kenya.
2.7 Research Gap

The preceding sections of this chapter reviewed empirical studies carried on the methods of teaching and learning of physics. This section will highlight some of these key studies and identify gaps upon which the current study was based on a study by Juan (2009) on totalizing didactic teaching learning process in physics.

Juan found out classroom teaching was largely appealing to cognitive domain and little on the affective and psychomotor domains. The current study was designed to bridge such gap by investigating the effects of teaching physics using the practical approach on student’s achievement in physics. Garuma and Tesfaye (2012) carried out a study to investigate the effect of guided discovery, demonstration and traditional teaching methods on students’ achievement in physics in Aba Bora Zone Ethiopia. They found that, the discovery method was the most effective method among the three. The current study was designed to investigate the effect of practical strategy as a guided discovery approach on students’ achievement in physics. The current one differs from the former in that the settings are different; former was conducted in Ethiopia and the later in Kenya. In addition, the main focus of the current was on practical work. Another critical study was that carried by Tesfaye and Getinet (2012) in Nigeria on the effect of question-answer instructional approach on students learning gains. The study was an experimental design just the current one but the later focused on the practical approach.

Silay (2010) conducted an experimental study on effects of problem-solving strategies on students’ achievements in physics, attitude and motivation in turkey. The current one focused on the effects of the practical approach on students’
achievement in physics and attitudinal change. The reviewed studies show that instructional interventions are likely to influence students’ achievements in physics and students’ attitude change towards the subject. However there are no documented studies in Kenya more so in Murang’a East sub-county on the effects of practical work on students’ achievement in physics. The current study was designed to address this gap.

2.8 Chapter Summary

The chapter has reviewed literature related to the current study. Specifically, the study looked at the importance of science education to the society, importance of physics to society, students’ attitude towards Physics and challenges faced in the Teaching and Learning of Physics. The chapter has also reviewed literature on methods of teaching physics including the traditional (conventional) and the practical approaches in the teaching of Physics. Finally, literature on the modern technologies in the practical approach in the teaching of physics was also reviewed. The study established that the effects of practical approach as an instruction on students’ achievements in physics have not been explored at least in Murang’a East County. The study was designed to address this gap.
CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction
This chapter focused on the methodology that was used in this study. The following issues were addressed; research design, location of the study, target population, sample size and sampling procedures, research instruments, pilot study, data collection methods and procedures, methods of data analysis and ethical considerations.

3.2 Research Design
The study adapted a quasi-experimental pretest-posttest design. It involved four schools in two categories: A and B. There were two schools from category A and two from category B. Each category had one experimental and one control group making a total of four groups. The four groups set for the pre-test achievements test at the start of the study. The experimental groups were then taught using the practical approach while the control groups were taught using the conventional method. This was done for one full-term of three months. Then the post-test achievements tests were administered and the results analysed. The rubrics for the design are presented in Figure 2.

<table>
<thead>
<tr>
<th></th>
<th>Experimental group</th>
<th>R</th>
<th>O₁</th>
<th>X</th>
<th>O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td></td>
<td>R</td>
<td>O₂</td>
<td></td>
<td>O₄</td>
</tr>
</tbody>
</table>

**Figure 2: Design for the Study**
Where $X = \text{Treatment}$

\[
\begin{align*}
\xmark & = \text{No treatment} \\
O_1 & \text{pre-test result for the experimental group} \\
O_2 & \text{pre-test result for the control group} \\
Q_3 & \text{post-test result for the experimental group} \\
O_4 & \text{post-test result for the control group}
\end{align*}
\]

A summary of the entire research design and process is displayed in Figure 3.
**Research Population**
Secondary schools in Murang’a East Sub-County. Purposive sampling

**Study Sample**
Four (4) secondary schools

Random sampling of Form Two students into experimental and control groups

**Sample 1**
Experimental group practical assisted instruction method

**Sample 2**
Control group
Conventional instruction method

**Pre-test**

**Data**

**Research topic**
Magnetism
Turning effect of a force
Centre of gravity equilibrium
Reflection of curved surfaces

**Treatment**

**Post - Test**

**Data Analysis**

**Data Presentation**

**Summary and Conclusion**

**Recommendations**

Figure 3: Study Design and Process
Figure 3 shows how the study was undertaken. Two groups were sampled to form the experimental and control group. The experimental group was given the treatment while the control group was not. The two groups were exposed to the post-test achievements test, the mean for each group was computed and the difference analyzed using the t-test.

3.3 Location of the Study
The study was located in secondary schools of Murang’a East Sub-County. The Sub-county has 31 secondary schools. The Sub-county was chosen due to the low enrolments in Physics and also the low students’ achievements in the subject in KCSE (Appendix 1).

3.4 Target Population
The target populations were the 9820 form two students of 31 secondary schools in Murang’a East Sub-County (County Education Office, 2013). The unit of analysis was the Form Two students in the 31 secondary schools. The sampling frame is shown in Table 2. The 31 schools were categorized into; two (2) private’s schools and one (1) national school, one (1) extra county school, three (3) District school and twenty four (24) Days school.

3.5 Sampling and Sampling Procedures
Purposive sampling was used to select the study sample. The study target those schools with low student low in Physics, low students’ achievements in Physics and have fully equipped laboratories because of the study. In addition, the schools chosen had to be at the same level of achievements. This was to ensure that the
prerequisite skills and the knowledge level of the students in Physics is almost the same. Schools with almost the same MSS in the past five at KCSE. Also one of the key resource that were required for practical work as a method of instruction is availability of a relatively functional laboratory with basic laboratory fittings. The sample was drawn from the Day schools’ category. This was because the schools’ in the category had low enrolments and low achievements in Physics in KCSE. Stratified sampling technique was used to select the sample. The Day schools were classified into two; those with a define MSS of between 4 -5 and those with a MSS between 3- 4 the 2012 KCSE results. From each stratum, two schools were purposively chosen totaling to a sample size of four schools. Sampled schools were far from each other to minimize interaction.

In addition they have the same MSS score per the KCSE results of 2012. They also have the same characteristics in terms of entry behaviour and infrastructure. The two purposively chosen schools in each stratum had similar characteristics; almost similar achievements in KCSE for the last three years, had a well equipped Physics laboratory and qualified Physics teachers. This ensured homogeneity of the sampled schools. They were also mixed (Boys & Girls) so as to capture the gender component. One school from each category formed the experimental group while the other the control group. Each of the sampled schools had two streams. Simple random sampling technique was used to select one stream/class. The names of the two streams were written on pieces of paper and placed in a basket. One class was randomly selected by picking only one piece of paper from the basket. The sampling grid is shown in Table 1
Table 1: Sampling Grid

<table>
<thead>
<tr>
<th>School Category</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>No. of Streams</th>
<th>No. of Classes Chosen</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Experimental school</td>
<td>4.54</td>
<td>4.26</td>
<td>4.69</td>
<td>2</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>Control School</td>
<td>4.84</td>
<td>4.56</td>
<td>4.701</td>
<td>2</td>
<td>1</td>
<td>46</td>
</tr>
<tr>
<td>B Experimental school</td>
<td>3.21</td>
<td>3.64</td>
<td>3.43</td>
<td>2</td>
<td>1</td>
<td>48</td>
</tr>
<tr>
<td>Control school</td>
<td>2.89</td>
<td>3.14</td>
<td>3.62</td>
<td>2</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>4</td>
<td>188</td>
</tr>
</tbody>
</table>

3.6 Research Instruments

There were four (4) instruments used in this study. Their development and roles are explained in the following section.

3.6.1 Pre-Test Achievements Test

Pre-test was used to measure the performance of the learners in Physics of both the experimental and the control group before the treatment is administered (Appendix VI). This aimed at ensuring that, both groups were of relative same ability in performance in Physics. The achievements test was composed of 22 structured questions which took 1 ½ hours.
3.6.2 Post-test
The Students Achievements Test (SAT) was administered to both experimental and control groups in a staggered manner throughout the term (Appendix VII). Specific tests evaluating the work done in each topic was given at the end of the topic. These was graded and eventually complied at the end of the term.

3.6.3 Form Two Students Attitude Scale (FTSAS)
This was administered at the beginning of the study and at the end of the study (Appendix X). The scale was based on a five point Likert type attitude scale. Strongly disagree (1) disagree (2) don’t know (3) agree (4) and strongly agree (5).

3.6.4 Observation Checklists for Skills Acquisition (OCFSA)
This was administered to each study group to determine proficiency aspects of science process skills and experimental achievements attitude (XI).

3.7 Piloting
A pilot study was undertaken for purposes of validation and testing the reliability of the research instrument that was used. Two mixed day Schools in the neighbouring Kirinyaga County were purposively chosen for piloting so as to capture the key characteristics of the study. The pilot study helped to identify and rectify the mistakes in set questions. It also helped to determine the suitability and the appropriateness of the language used in both pre-test and post-test. It also helped in making any adjustment to the practical set up and write ups.
3.7.1 Validity of the Instruments

Content and construct validity of the research tools were initiated at the design stage. Some of the items used in the achievements tests were adapted from KNEC (2008, 2009 & 2010). The test items were constructed using the Form Two syllabus. These strengthened both content and construct validity. This stage was followed by the pilot study whose main purposes were to check the appropriateness of the language used in the tools and to conceptualise them for predictability and reliability. The pre-test and post-tests were developed with the assistance of three experts in Science Education in Department of Educational Communication and Technology at Kenyatta University and two KNEC Physics Examiners in 231/1-paper one. The Form Two Students Attitude Scale (FTSAS) was adapted from Tapia & Marsh (2004).

3.7.2 Reliability of the Instrument

The reliability of the assessment test was determined using the split-half method. This is where the total number of items were divided into halves by assigning the odd numbered items to one half and even numbered items to the other half. Correlation between the two halves was determined. Spearman-brown prophecy formula was used to estimate the reliability of the whole test. The Spearman–Brown prophecy formula adopted from Elzinga, et al., (2001) was used.

\[ P_{XX}^{11} = \frac{2p_{xx}^1}{1 + p_{xx}^1} \]

Where \( P_{XX}^{11} \) is the reliability co-efficient for the whole test and \( P_{xx}^1 \) is the split half correlation if it was 0.7 and above then the test was considered reliable. A
reliability coefficient of 0.83 and 0.87 were obtained for the Pre-test and posttest tests respectively. The Form Two Students Attitude Scale (FTSAS) was adapted from Tapia & Marsh (2004). The scale has a reliability coefficient of 0.96.

### 3.8 Data Collection Methods and Procedures

At the beginning of the term the four groups were given a standard achievements test which served as a pre-test. This pre-test was based on work covered previously. The results from this test were analysed to ascertain the relative achievements levels of both the experimental and the control groups. At the beginning of the study, the teachers who were involved in the study underwent training exercise to familiarize themselves with the practical approach. The students were taught using the practical approach for the experimental group and the conventional method for the control group for a period of one term. The topic taught were: Moment and Force, center of gravity and equilibrium, magnetism and reflection of curved surfaces. These topics were selected from the syllabuses as stipulated by Kenya Institute of Curriculum Development (KICD) and Kenya National Examination Council (KNEC).

During the term the teachers were oriented on how to use the practical approach in their teaching method. The respondents were taught using two instructional techniques, that is, the practical approach and the conventional method over a period of one term. The experimental group instructional technique emphasized practical work when teaching the topics. During the practical activity the respondents were actively involved in setting the equipment and apparatus used in the laboratory. After each experiment, there was an intensive class interaction. Experimental procedure, data collection, manipulation and analysis procedures were reviewed in
the class before the respondents were required to complete writing the final laboratory report. In the control group the conventional method of teaching was used. The students achievements tests (SAT) was administered to the respondents in a staggered manner throughout the term. Specific tests evaluating the work done in each topic was given out at the end of each topic. This formed the post-test scores.

All the students in the two groups were given a Form Two Students Attitude Scale, (FTSAS). The scale was based on a five point Likert type attitude towards Physics learnt up to form two. The respondents proficiency in practical skills garnered from each of the topics learnt in class was determined using the Observation Checklists for Skills Acquired (OCFSA) administered to each study group. The OCFSA determined proficiency in aspects of science process skills. Finally during term one the next year; the same respondents were tracked to find out how many of them had chosen to study Physics in form three.

3.9 Methods of Data Analysis

The data collected underwent various stages of preparation before the analysis using the Statistical Package for Social Sciences (SPSS) computer software. First, the data were edited and coded. A code book was then used to prepare computer code sheet, which was later used to synthesize the data. Upon completion of data entry, the data was cleaned to detect and remove any errors committed during data entry. Simple frequency analyses on the variables were run and random cross-tabulation done to clean the data.

Data germane to the study was both quantitative and qualitative. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) Version 21.0.
Quantitative analysis involved presentation of statistical data in form of frequency distribution tables whose explanation was mainly descriptive and inferential statistics. The statistical significance of the results was then examined at $\alpha = 0.05$ statistical confidence level. Quantitative data was analyzed using independent t-test.

For objective one, the student’s t-test was used to compare if there was significant difference in the means between the control and experimental groups in the pre-tests and post-tests. The student t-test was used to establish the significant difference in means in Physics achievements between those students taught Physics using the practical approach and those taught using the conventional method. In the respect to the students’ attitude towards Physics, the student t-test was also used to establish the significant difference in MSS in the attitude scale between pre-test and post-tests for both the control and the experimental groups.

For the science process skills, the Observation Checklists for Skills Acquisition (OCFSA) was used to collect quantitative data. Student t-test was also used to establish the significant difference in the mean of students’ achievements in the science process skills between the experimental and control groups. For objective two, a prototype marking scheme for the evaluation of Science Process Skill was developed based on the evaluation scheme for the experimental groups in Practical work.

3.10 Ethical Consideration

The researcher sought a research permit to carry out the research from National Council for Science, Technology and Innovation (NACOSTI). The sampled schools were visited to seek permission to carry out the research from the schools’
administration. A meeting with Form Two teachers of Physics was organized so as to induct them into the study. They filled consent forms to participate in the study. The students also filled the consent forms before being engaged in the study. The participants filled a consent form before participating in the study. They were also assured of confidentiality and that the information provided would be used for the purposes only.
CHAPTER FOUR
DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.0 Introduction

This chapter presents, interprets and discusses the findings generated from this study and reported using mainly tabular mode. The chapter specifically considers and explains effects of practical work in Physics on students, in particular achievements in Physics, acquisition of science process skills, attitude change towards Physics, scheme for evaluating practical work in secondary schools Physics and enrolment in Physics at KCSE.

4.1 Effects of Practical Work in Physics on Students’ performance in Physics

In order to establish the effects of practical work in Physics on student’s performance in Physics, the respondents were first subjected to a pre-test to determine their equivalence about ability in physics. A Physics Achievements pre-test was used for this purpose.

4.1.1 Students’ Performance the Physics Achievement Pre-Test

The results of the students’ achievements on the pre-test are presented in Table 2.
Table 2

Mean Scores of the Pre-Test per Group

<table>
<thead>
<tr>
<th>Group (School)</th>
<th>n</th>
<th>Mean</th>
<th>Std Deviation (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental A</td>
<td>45</td>
<td>27.73</td>
<td>7.817</td>
</tr>
<tr>
<td>Control A</td>
<td>48</td>
<td>27.17</td>
<td>5.513</td>
</tr>
<tr>
<td>Experimental B</td>
<td>46</td>
<td>25.24</td>
<td>8.239</td>
</tr>
<tr>
<td>Control B</td>
<td>49</td>
<td>25.31</td>
<td>7.177</td>
</tr>
<tr>
<td>Total</td>
<td>188</td>
<td>26.35</td>
<td>7.266</td>
</tr>
</tbody>
</table>

Table 2 results show that the experimental and control groups are fairly equivalent in ability in Physics. This underscores the fact that both the experimental and control groups were starting on a fairy even ground. The equivalence of the groups was confirmed by the t-test using their means. The differences in means were not significant.

Table 3

Comparison of Mean Scores of Experimental and Control A Groups

<table>
<thead>
<tr>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Experimental A</td>
</tr>
<tr>
<td>Control A</td>
</tr>
</tbody>
</table>

Table 3 shows that there was no significant mean difference in the performance of pre-tests between experimental and control schools in set A school, t (91) = 4.06, ρ = 0.686, α = 0.05). An independent t-test was also conducted for the schools set B. The results are presented in Table 4.
Table 4
Comparison of Mean Scores of Experimental and Control for set B Groups

<table>
<thead>
<tr>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental B</td>
<td>46</td>
<td>25.24</td>
<td>.042</td>
<td>93</td>
<td>.966</td>
</tr>
<tr>
<td>Control B</td>
<td>49</td>
<td>25.31</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows that an independent t-test conducted absolute t (93) = 0.042, \( \rho = 0.966 \), \( \alpha = 0.05 \) revealed that there was no significant difference between the experimental and control schools in set B in the performance of pre-test as shown in Table 5 and 6.

4.1.2 Students’ performance in the Post-Test

The experimental group was taught for a full school term using a practical approach while the control group went on with the conventional approach which does not use many practical sessions. At the end, a post test was administered (see Appendix VII). The results are as in Table 5.

Table 5
Students’ performance in the Post-Test Achievement Test

<table>
<thead>
<tr>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental A</td>
<td>45</td>
<td>34.60</td>
<td>9.521</td>
</tr>
<tr>
<td>Control A</td>
<td>48</td>
<td>27.25</td>
<td>5.526</td>
</tr>
<tr>
<td>Experimental B</td>
<td>46</td>
<td>30.70</td>
<td>7.586</td>
</tr>
<tr>
<td>Control B</td>
<td>49</td>
<td>27.04</td>
<td>6.377</td>
</tr>
<tr>
<td>Total</td>
<td>188</td>
<td>29.08</td>
<td>7.918</td>
</tr>
</tbody>
</table>
Table 5 shows that the experimental groups in both cases performed higher than the control groups. For group A the experimental group had a mean = 34.6 while the control group had mean = 27.25. On the other hand, in group B, the experimental group had (mean = 30.7) while the control group had (mean = 27.04. This clearly shows that the intervention was effective and that practical approach is more effective.

**Table 6**

**Independent t-test for the Post-Test**

<table>
<thead>
<tr>
<th>Set</th>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>T</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Experimental A</td>
<td>45</td>
<td>34.6</td>
<td>4.588</td>
<td>91</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Control A</td>
<td>48</td>
<td>27.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Experimental B</td>
<td>46</td>
<td>30.7</td>
<td>2.548</td>
<td>93</td>
<td>.012*</td>
</tr>
<tr>
<td></td>
<td>Control B</td>
<td>49</td>
<td>27.04</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level

Table 6 shows that there was a significant difference for the two sets A and B. It was more significant for A (M = 34.60) and control school A (M = 27.25), t (91) = 4.588, $\rho > .0001$, $\alpha = .05$ than for school B (M = 30.70) and Control B (M =27.04), t (93) = 2.548, $\rho = .012$, $\alpha = .05$. A Tukey’s HSD Multiple Comparison test was then conducted. The results are presented in Table 7
Table 7
Comparison of Mean Scores of Post-Test among the Four Schools

<table>
<thead>
<tr>
<th>(I) Four groups</th>
<th>(J) Four groups</th>
<th>Mean differences (I-J)</th>
<th>SE</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental A</td>
<td>Control A</td>
<td>7.350*</td>
<td>1.527</td>
<td>.000</td>
</tr>
<tr>
<td>Experimental B</td>
<td></td>
<td>3.904</td>
<td>1.543</td>
<td>.059</td>
</tr>
<tr>
<td>Control B</td>
<td></td>
<td>7.559*</td>
<td>1.579</td>
<td>.000</td>
</tr>
<tr>
<td>Experimental B</td>
<td>Experimental A</td>
<td>-3.904</td>
<td>1.543</td>
<td>.059</td>
</tr>
<tr>
<td></td>
<td>Control A</td>
<td>3.446</td>
<td>1.518</td>
<td>.109</td>
</tr>
<tr>
<td></td>
<td>Control B</td>
<td>3.655</td>
<td>1.511</td>
<td>.077</td>
</tr>
<tr>
<td>Control A</td>
<td>Experimental A</td>
<td>-7.350*</td>
<td>1.527</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Experimental B</td>
<td>-3.446</td>
<td>1.518</td>
<td>.109</td>
</tr>
<tr>
<td></td>
<td>Control B</td>
<td>.209</td>
<td>1.495</td>
<td>.999</td>
</tr>
<tr>
<td>Control B</td>
<td>Experimental A</td>
<td>-7.559*</td>
<td>1.519</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Control A</td>
<td>-.209</td>
<td>1.495</td>
<td>.999</td>
</tr>
<tr>
<td></td>
<td>Experimental B</td>
<td>-3.655</td>
<td>1.511</td>
<td>.077</td>
</tr>
</tbody>
</table>

* Significant at .05 level

Table 7 shows that there is a significant mean difference between experimental A and control school A (7.350), \( \rho = .001 \) and between experimental B and control B (7.559), \( \rho = .001 \). The study may attribute the significant mean difference to practical work which enhanced acquisition of skills resulting in better achievements.

Considering the first hypothesis, \( H_0 \), that there is no significant difference in students’ performance in Physics between those taught in a practical way and those not exposed to practical work, hypothesis one was rejected. The study then accepted the alternative hypothesis, \( H_1 \): There is a significant difference in student performance in Physics for Form Two students taught Physics through practical work and those not taught through practical work. The study concluded that the
students exposed to practical work in Physics performed better than those taught through conventional method. Wasanga (2009) also found a similar correlation between practical work and understanding of science subjects which leads to improved achievements in achievements tests. Amunga et al., (2011a) 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.

Lunetta et al., (2007) suggested that engaging in scientific practical work provides simulation experiences which situate students learning in states of inquiry that require heightened mental and physical engagement. This engagement leads to better understanding and improved achievements. However, Hodson (1991) casts cautionary aspersions on the relationship between practical work and achievements in secondary schools. The thrust of his argument is that experimental attempts in the average high schools are sterile and un-illuminating. According to him, the practical work is ill conceived, confused and unproductive. It does not translate into tangible achievements bonuses for the learners. Also, Hofstein (1982) points out that too much emphasis on laboratory activity leads to a narrow conception of the content.

According to Millican, Richards & Mann (2005) Physics is an experimental subject. General principles and concepts are more easily understood if they are demonstrated in the laboratory. Laws and relationships are more fully appreciated if the student investigates and verifies them at the laboratory bench. The study therefore
concluded that practical work in Physics as an instructional strategy significantly contributes to students’ achievement in Physics.

4.2 Effect of Practical Work in Physics on Students’ Attitude towards the subject

The study was also designed to establish the effects of practical work in Physics on students’ attitude change towards Physics. For systematic presentation of the findings in this area, the study presented the result of the students’ pre-test attitude towards Physics between the experimental and control groups and then followed by post-test attitude towards Physics and finally compared the two.

4.2.1 Pre-Test Students’ Attitude towards Physics scale

Each statement in the scale was rated on a scale of 1 to 5 that is strongly disagree, disagree, neutral, agreed and strongly agreed respectively. There were a total of 27 statements (Appendix X). This implied that a student could get a maximum score of 135 (27 x 5 points) or minimum score of 27 points (27 x 1). The total scores for each respondent were computed. The mean score per student was then computed. Finally, the average score for each school was determined. Student’s t-test was then performed to determine whether there is significant difference in the mean scores on students’ attitude towards Physics between the experimental and control groups. The results are presented in Table 8.
<table>
<thead>
<tr>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>S.D</th>
<th>t</th>
<th>df</th>
<th>Sig. (2tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental A</td>
<td>45</td>
<td>3.60</td>
<td>9.880</td>
<td>1.86</td>
<td>91</td>
<td>.853</td>
</tr>
<tr>
<td>Control A</td>
<td>48</td>
<td>3.58</td>
<td>9.988</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental B</td>
<td>46</td>
<td>3.77</td>
<td>10.851</td>
<td>1.482</td>
<td>93</td>
<td>.142</td>
</tr>
<tr>
<td>Control B</td>
<td>49</td>
<td>3.65</td>
<td>9.853</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at $\alpha = .05$

Table 8 shows that the experimental group A (M = 3.60, SD = 9.880) had a higher mean attitude towards Physics than control A (M = 3.58, SD = 9.988). However, these results show that there was not statistically significant difference in the means of the two groups. The experimental school B had also a higher mean attitude towards Physics (M = 3.77, SD = 10.85) than the control school B (M = 3.65, SD = 9.853). These results show that there was no statistically significant mean difference between the experimental and control groups. This is important as it shows that the experimental and control group started off at the same level in terms of attitude towards Physics.

### 4.2.2 Post-Test Students’ Attitude towards Physics

The results of the post-test students’ attitude towards Physics scale results are presented in Table 8. The students Attitude scale that was used during the pre-test was administered at the end of the intervention so as to establish if the students’ attitude towards physics had changed. The results are presented in Table 9.
Table 9
Post-Test Students’ Attitude towards Physics

<table>
<thead>
<tr>
<th>School</th>
<th>n</th>
<th>Mean</th>
<th>S.D</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>45</td>
<td>3.90</td>
<td>10.710</td>
<td>3.117</td>
<td>91</td>
<td>.002*</td>
</tr>
<tr>
<td>Control</td>
<td>48</td>
<td>3.65</td>
<td>10.291</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>46</td>
<td>3.93</td>
<td>10.159</td>
<td>3.404</td>
<td>93</td>
<td>.001*</td>
</tr>
<tr>
<td>Control</td>
<td>49</td>
<td>3.67</td>
<td>9.06</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05

Table 9 shows that experimental school A had a higher mean attitude towards Physics (M = 3.90, SD = 10.710) than control school A (M = 3.65, SD = 10.291). The difference between the two groups, t (91) = 3.117, p = .002, α = .05. This implies that the experimental group taught Physics through practical work had a better attitude towards the subject than those taught through the conventional method.

Table 9 also shows that the experimental school B had a higher mean attitude towards Physics (M = 3.93, SD = 10.159) than the control school B (M = 3.67, SD = 9.06). The t-test performed shows that there was a significant mean difference between the two schools in sample set B in attitude towards Physics t (93) = 3.404, p = .001, α = .05). This also confirms that practical work approach improves attitude towards the subject than those taught through the conventional method.
4.2.3 Comparison between the Pre-Test and Post-Test Students’ Attitude towards Physics

The results of the comparison between the pre-test and post-test students’ attitude towards Physics scale are presented in Table 10.

Table 10
Comparison between the Pre-Test and Post-Test Students’ Attitude towards Physics

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Mean</th>
<th>Difference</th>
<th>S.D</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pre-test</td>
<td>post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental A</td>
<td>45</td>
<td>3.60</td>
<td>3.90</td>
<td>+ 0.3</td>
<td>6.583</td>
<td>-8.287</td>
<td>44</td>
<td>.000*</td>
</tr>
<tr>
<td>Control A</td>
<td>48</td>
<td>3.58</td>
<td>3.65</td>
<td>+ 0.07</td>
<td>5.139</td>
<td>-2.331</td>
<td>47</td>
<td>.240</td>
</tr>
<tr>
<td>Experimental B</td>
<td>46</td>
<td>3.78</td>
<td>3.94</td>
<td>+ 0.16</td>
<td>4.783</td>
<td>-6.474</td>
<td>45</td>
<td>.000*</td>
</tr>
<tr>
<td>Control B</td>
<td>49</td>
<td>3.65</td>
<td>3.69</td>
<td>+ 0.04</td>
<td>2.078</td>
<td>-1.865</td>
<td>48</td>
<td>.068</td>
</tr>
</tbody>
</table>

*significant at 0.05

Table 10 shows that there was a mean gain of + 0.3 in the attitude change for experimental school A, which was significant (t (44) = 8.287, ρ = .001, α = .05). There was a similar case for experimental school B where there was a mean gain in students’ attitude towards Physics from pre-test to post-test of + 0.16. This gain was significant (t (45) = 6.474, ρ = 0.0001, α = 0.05). However there was no significant mean gain in students’ attitude towards Physics for the control groups. For control School A, the mean gain was +0.16 which was not significant (t (47) = 3.222, ρ = 0.240, α = 0.05). For control school B, the mean gain was only +0.04 which was also not significant, (t (48) = 2.078, ρ = 0.068, α = 0.05).
The study, therefore, rejected the second hypothesis $H_02$ that there is no significant difference in attitudinal change towards Physics for students’ taught Physics through practical work and those taught through conventional method. The study accepted the alternative hypothesis; $H_02$, there is a significant mean difference in attitude change towards Physics for students taught Physics through practical work and those taught through the conventional method.

Table 10 also shows that experimental school A had a higher mean attitude towards Physics ($M = 3.90$, $SD = 10.710$) then control school A ($M = 3.65$, $SD = 10.291$). The difference between the two groups, $t (91) = 3.117$, $\rho = .002$, $\alpha = .05$. This implies that the experimental group taught Physics through practical work had a better attitude towards the subject than those taught through the conventional method. The findings of this study concerning respondent formed attitudes concur with the observations of Talisayon (2006) who found out that learner developed improved attitudes towards science as a result of practical courses. Kim & 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. Toplis and Allen (2012) suggest 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. This understanding leads to a feel good attitudinal disposition to the subject under study.

This research also confirms that students taught using practical approach had a better attitude towards the subject than those taught through the conventional method.
Research has shown that there is attitude change towards science on exposure to science, but the direction of change may be related to the quality of that exposure, the learning environment and teaching method (Craker, 2006). Musyoka (2000) found that a majority of students who were not taking Physics for instance were scared of its quantitative nature and the conception that Physics is too abstract especially when taught theoretically. According to Adesina & Akinbobola (2005) attitudes are acquired through learning and can be changed through persuasion using a variety of techniques. Attitudes once established help to shape experiences the individual has with object, subject or person. Although attitudes can change gradually, people constantly form new attitudes and modify old ones when they are exposed to new information and experiences.

The study established a significant difference in attitude change towards Physics for students taught Physics through practical and those taught through conventional methods. Minambo (2013) in his book titled ‘deciding your destiny’ said that the attitude and the perception we have on any event determine energy and the attention we give towards performing the event. Nouhi, Shakoori and Nakhei (2008) added that mastering skills by students makes study more enjoyable and effective which in turn strengthen the students’ interest so that he/she spends more time studying. Research has made us know that the attitude towards science change with exposure to science, but the direction of change may be related to the quality of that exposure, the learning environment and teaching method (Craker, 2006).
4.3 Effect of Practical Work on Acquisition of Science Process Skills in Physics

The fourth objective of the study was to determine the effect of practical work in Physics on students’ acquisition of science process skills. To this end the science process skills investigated a range of skills which included, observation, measuring, classifying, recording and interpretative. The proficiency in these five skills was determined using a checklist for these skills (Appendix XI). The t-test for both experimental and control groups in the two categories of schools was calculated and the results are presented in Table 11.

Table 11

<table>
<thead>
<tr>
<th>School Category</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>S.D</th>
<th>t</th>
<th>df</th>
<th>Sig. (2 tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Experimental A</td>
<td>45</td>
<td>57.29</td>
<td>14.533</td>
<td>5.452</td>
<td>91</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Control A</td>
<td>48</td>
<td>43.71</td>
<td>9.015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Experimental B</td>
<td>46</td>
<td>47.02</td>
<td>13.046</td>
<td>3.680</td>
<td>93</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Control B</td>
<td>49</td>
<td>39.02</td>
<td>7.603</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at 0.05

Table 11 show that both the experimental and control exhibited high levels acquisition of science process skills. The experimental group in school category A performed better in the science process skills (M = 57.29, SD = 14.533) than the control group (M = 43.71, SD = 9.015). The study attributed this better acquisition of science process skills for the experimental group due to exposure to the practical skills during the teaching. The control group learnt Physics through the conventional method but the experimental group acquired the science process skills during
classroom instruction of practical work in Physics. Similarly the experimental group in school category B also performed better (M = 47.02, SD = 13.05) then the control group (M = 39.02, SD = 7.6). This was also attributed to the practical work in Physics instruction accorded to the experimental group. Both results were significant at .0001.

The study thus concluded that, there was a significant difference in acquisition of science process skills for Form Two sets of experimental students taught through the experimental and conventional methods. The study therefore rejected the null hypothesis \( H_0 \) that, there is no significant difference in acquisition of science process skills for students taught Physics through practical work and those taught through the conventional method. The study therefore accepted the alternative hypothesis, \( H_3 \), there is a significant mean difference in acquisition of science process skills for students taught Physics through practical work and those taught through the conventional method. The experimental group in category A schools performed better in the science process skills. The study attributed this better acquisition of science process skills for the experimental group due to exposure to the practical skills during the teaching. The control group learnt Physics through the conventional method but the experimental group acquired the science process skills during classroom instruction of practical work in Physics. These findings concur with those of Inal (2003) who found that the basic science process skills were picked and consolidated by secondary school practical work. He adds that the learners picked up information and skills more quickly when they actually did the experiment compared to when they were simply lectured in class. The learners
reported valuing the role of all the senses in learning and the fact that they came to their own conclusions. Looking at and touching the apparatus and equipment made the conclusions of the experiments believable.

The study results also agree with Miles (2010) who found out that science process skills were associated with content familiarity, interest and display of conceptual knowledge. These findings generally agree with those of this study which put the control group at a disadvantage in the acquisition of the basic science process skills. Tifi et al., (2006) suggest that investigations allow learners to reach their own conclusions. Science process skills have been described as mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development (Nwosu & Okeke, 1995).

Shi et al., (2011) have demonstrated that the basic science process skills are gained more readily when practical work involving springs are performed by the learners accompanied by detailed discussions about the nature and purpose of the experiments. Coil et al., (2010) in their study involving university and high school faculty have stressed the importance of science process skills as the foundation of the scientific enterprise for learners. They indicated that these skills were gained principally through experimentation and practical work. They asserted that science process skills enhanced current and future science content. Chabalengula et al., (2012) have demonstrated the usefulness of mastery of science process skills among elementary school science teachers.
The findings from the current research are in tandem with several research findings on the acquisition of practical experimental skills. Frost (2010) suggests that most illustrative practical work requires that teachers transfer the task of setting up practical activities to the learners so that they can gain in proficiency and expertise. The core intention is to collect record and manipulate data be it digital or analog in order to obtain patterns that explain the data in investigations concerning various topics. They aver that more exposure to the practical situation the more the practical skills are mastered.

Keys and Bryan (2001) assert that science process skills can be developed by engaging learners in authentic learning activities. These are activities that should provide learners with design investigations for solving these problems. These require teachers to adopt inquiry-based approaches to science teaching and learning. It has been observed from studies carried out by Smolleck et al., (2006) & Lanka (2007) that school laboratory experiences introduce important aspects of science to students while simultaneously assisting them in developing knowledge in regard to specific science concepts

4.4 Effect of Practical Work on Enrollment in Physics

The fourth objective was to determine the effects of practical work in Physics on students’ enrolment in Physics. To this end, the number of students enrolled in Physics in Form Three was compared for the experimental and control groups in categories A and B. The results are presented in Table 12.
Table 12
Students’ Enrolment in Physics for both Experimental and Control Groups

<table>
<thead>
<tr>
<th>School Category</th>
<th>Group</th>
<th>n</th>
<th>Number Enrolled In Form 3</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Experimental</td>
<td>45</td>
<td>17</td>
<td>37.7</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>48</td>
<td>11</td>
<td>22.9</td>
</tr>
<tr>
<td>B</td>
<td>Experimental</td>
<td>46</td>
<td>16</td>
<td>34.8</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>49</td>
<td>11</td>
<td>22.4</td>
</tr>
</tbody>
</table>

Table 12 shows that majority 17(37.7%) of the students in experimental school category A enrolled for Physics compared to 11(22.9%) from the control school in the same category. Similarly, majority 16 (34.8%) from the experimental school in school category B enrolled to pursue Physics in form three compared to only 11 (22.4%) students who enrolled from the control school in category B. The study attributed the difference in enrolment as a result of instruction in Physics through practical work accorded to the experimental schools. The study correlated the enrollment in Physics in form three with the students score in the post-test attitude scale towards Physics. The results were presented in Table 13.
Table 13
Correlation between Enrolments in Physics in Form 3 with Scores in the Post-Test Attitude towards Physics Scale

a) Experimental School in Category A schools

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.26*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.043</td>
</tr>
<tr>
<td>n</td>
<td>45</td>
</tr>
</tbody>
</table>

b) Control School in Category A

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.06</td>
</tr>
<tr>
<td>Sig.(2-tailed)</td>
<td>.097</td>
</tr>
<tr>
<td>n</td>
<td>48</td>
</tr>
</tbody>
</table>

(c) Experimental Group in Category B

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.18</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.032</td>
</tr>
<tr>
<td>n</td>
<td>46</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.18</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.032*</td>
</tr>
<tr>
<td>n</td>
<td>46</td>
</tr>
</tbody>
</table>

* Significant at .05 level
Table 13 shows that there is a significant positive correlation between the students’ attitude towards Physics and their enrolment for the experimental groups. For the experimental group in category A schools $r (45) = .26$, $\rho = .043$, $\alpha = .05$ while that of category B schools was $r (46) = .18$, $\rho = .032$, $\alpha = .05$. For the control groups there is a weak positive relationship between students’ attitude and enrolment. For the control school in category A, $r (48) = .06$, $\rho = .097$, $\alpha = .05$ while that of category B, $r (49) = .79$, $\rho = .081$, $\alpha = .05$. The above results show that practical work improved the students’ attitude towards Physics. This perhaps could have led to higher student enrolment in Physics. The study therefore concluded that there was a significant difference in enrolment in Physics for the students taught through practical work and those taught through the conventional method. Therefore, the null hypothesis $H_04$, there is no significant difference in enrolment in Physics for Form Two students taught Physics through Physics practical work and those not taught through practical work at Form 3, was rejected and the alternative accepted. Thus, the study concluded that, there is a significant difference in enrolment in Physics for

### Table 13

<table>
<thead>
<tr>
<th></th>
<th>Attitude</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitude</strong></td>
<td>Pearson Correlation 1 .79</td>
<td>.79</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-Tailed) .081</td>
<td>n 49</td>
</tr>
<tr>
<td><strong>Enrolment</strong></td>
<td>Pearson Correlation .79</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-Tailed) .081</td>
<td>n 49</td>
</tr>
</tbody>
</table>

**d) Control Group in Category B**
Form Two students taught Physics through Physics practical work and those not taught through practical work at Form 3.

The study concluded that teaching Physics through practical work had a positive effect on building a positive attitude towards Physics which in turn lead to higher enrolment. For the experimental group in category A schools $r (45) = .26, \rho = .043, \alpha = .05$ while that of category B schools was $r (46) = .18, \rho = .032, \alpha = .05$. For the control groups there is a weak positive relationship between students' attitude and enrolment.

Table 13 also shows that there was a significant positive correlation between the students’ attitude towards Physics and their enrolment for the experimental groups. The study therefore concluded that there is a significant difference in enrollment in Physics for the students’ taught through the conventional method. The study concurs with Williams et al., (2003) who investigated the issue of why students are not interested in studying Physics in higher secondary school classes. They found out that interest in and actual participation in practical experimental work during foundational secondary school education was a strong factor in deciding to pursuance of the subject in later secondary school. Assefa et al., (2008) have determined that amongst other intervention remedies for boosting enrollment in advanced Physics courses, ensuring participation in practical work was rated highly. It made students most ardent about the subject.

Physics is considered as the most problematic area within the realm of science, and it traditionally attracts fewer students than chemistry and biology (Rivard & Straw, 2000). Maguswi (2011) reported that Physics in Zambia was generally referred to as
an underachievement subject therefore not many students were willing to study it. Mekonnen (2014) observed that Physics had the lowest enrolment among undergraduate students in Ethiopia universities. According to Erinsho (2013) only few students in Nigeria shows interest and studied Physics. Alao & Abubakar (2010) found out that Physics is having a problem of low enrolment in Nigerian schools. This current study agrees with Millar (1998) who has suggested that practical work should be viewed as the mechanism by which materials and equipment are carefully and critically brought together to aid the Physics learner to understand about the veracity and validity of the scientific world view.

In the current study, the students’ enrolment in Physics at Form in the Experimental school A was 17 (37.7%). This is the likely candidature in KCSE in 2016. The percentage students’ enrolment in Physics for the same school between 2011-2013 was between 27.5, 25.9 and 26.2 respectively (Appendix IV). This showed an increase in percentage of students who enrolled for Physics. This could be attributed to the intervention of practical approach to Physics teaching. Similar results were recorded in the experimental group in school category B. The percentage enrolment in Physics in KCSE between 2011-2013 was 32.3%, 29.6% and 29.4% respectively. The current study found that the percentage enrolment for the experimental school B was 34.8%. This was also higher than the previous years. Perhaps the increase can be attributed to the practical approach to Physics instruction. The control group from the school category A had a student Physics enrolment in KCSE of 23.7%, 26.3% and 26.9% in 2011, 2012 and 2013 respectively (Appendix IV). This study found
that the school had a student enrolment of 22.9% in Physics at Form 3. This shows that the percentage is within the trend of the previous years.

The students’ percentage enrolment in Physics between 2011-2013 for the control group in school category B was 28.9%, 26.3 and 25.6 respectively. The current study found out that, the percentage enrolment in Physics for the control group was 22.4%. Though the enrolment was lowest compared to the past three years, it was within the trend. This status quo can perhaps be attributed to the use of the conventional method in teaching Physics in all the four years.

4.5 Development of a Prototype Scheme for Evaluating Practical Work in Secondary School Physics

Process skills in science are skills that students need to be able to investigate scientific problems. Understanding of science involve investigating the natural world using a combination of simple tools like thermometers, rulers, micrometer, screw gauge lenses ammeter, voltmeter etc, together with skills like observation, measuring, recording data, graphing, inferring, prediction etc. Some of the science skills and processes students need to develop include observation, classifying, inferring, measuring, communicating, predicting and hypothesizing. Process skills are thinking skills that students use when separating evidence from opinion. They are strategies for achieving scientific understanding. The objectives of this research were to show that practical approach as a central tool for teaching can enhance learning outcome than the conventional method of teaching. Practical assessment is based on the final outcome that is, the product rather than the process itself. Therefore, a scheme for evaluating the scientific processes is necessary if this
method is to be effective. Evaluation has a feedback component and can help students to perform. The various scientific activities have a positive effect on their understanding of the concepts. The acquisition of skills should be the main goal of performing an experiment. Therefore teachers of Physics and science in general should be in a position to evaluate the practical work as it progresses using some schemes that have been carefully constructed.

**Scheme for evaluating practical work in secondary school Physics**

**Manipulative skills**

a) Efficient use of fixing and arranging equipment

b) Correct operational sequence

c) Proficiency in utilizing equipment

**Observation emphasizes should be placed on the ability of students to:**

a) Read instructions correctly

b) Observe accurately

c) Record observations correctly

**Concluding**

a) Report writing

b) Mode of presentation of diagrams etc

**Skills to be evaluated**

a) Understand the equipment being used

b) Handling of the equipment

c) Assessing the equipment
Measurement

a) Accessing and reading instruments
b) Scale reading of the equipment
c) Reading the equipment used

Observation

a) Preliminary observation
b) Correct observations
c) Accurate recording of observation

Classification

a) Ability to classify
b) Simple classification
c) Correct classification

Inference

a) Attempt at making inference
b) Correct reference
c) Logical inference

Predicting

a) Use of prior knowledge to predict
b) Attempt to predict
c) Logical prediction

Communicating

a) Ability to communicate scientific language
b) Method of communication
c) Fluency in communication
A scheme in a tabular form was constructed and then applied (used) in practical situations.

Skills to be tested

<table>
<thead>
<tr>
<th>Expt No.</th>
<th>Observation</th>
<th>Measurement</th>
<th>Classifying</th>
<th>Inferences</th>
<th>Predicting</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each skill is rated in a scale of 1-100. The student’s level of achievements in each skill is evaluated and judgment on level of confidence done as follows:

<table>
<thead>
<tr>
<th>0-9</th>
<th>10-30</th>
<th>31-50</th>
<th>51-70</th>
<th>71-90</th>
<th>Above 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>No confidence</td>
<td>Low confidence</td>
<td>Moderate confidence</td>
<td>High confidence</td>
<td>Very high confidence</td>
<td>Complete confidence</td>
</tr>
</tbody>
</table>

This implies that for every skill there will be different rating depending on the practical.

a) Observing
b) Inferring
c) Predicting
d) Classifying
e) Measuring
f) Communicating
The study developed a flow chart linking the two instructional strategies—Practical approach and Conventional approach, achievements in Physics and enrolment. This is presented in Figure 4.

**Figure 4: Flow Diagram showing Relationship between instructional approaches in Physics and Students’ Achievements in the subject**
Figure 4 shows that the practical approach to instruction in Physics leads to acquisition of more skills, creates motivation in the learner leading to greater understanding. Higher achievements lead to higher enrolment. The reverse is true with conventional teaching. Learners are less motivated, acquire less skills leading to limited understanding. Low achievements follows and thus low enrolment results.
CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction
This chapter presents the summary of the findings, draw conclusions and make recommendations based on the conclusions.

5.2. Summary of the Findings
The first objective of the study was to establish the effects of practical work in Physics on student’s performance in Physics. The study found out that the experimental school A performed better than control school A while control school B (M = 25.31, SD =7.177) performed better than the experimental school B. An independent t-test revealed that there was no any significant mean difference between experimental school A and control schools in set A in the performance of the pre-test, t (91) = 4.06, ρ =.686, α =.05 it also showed that was no any significant mean difference between the experimental and control schools in set B in the achievements of pre-test, t (93) = .042, ρ =.966, α =.05. The study further showed that the experimental school in category A (M = 34.60 S.D = 9.521) performed better than the control school A (M =27.25 SD = 5.526). In addition, experimental school in category B (x̄ =30.70 S.D = 7.586) performed better than the control school B (M = 27.04, SD = 6.377). An independent t-test was then computed to determine if there was no mean significant difference between the control and experimental group from each set of school. The study revealed that there was a significant mean difference between experimental school A (M=34.60) and control
school A (M =27.25), t (91) = 4.588, \( p = .0001, \alpha = .05 \). In addition there was a significant mean difference between the experimental school B (M =30.70) and Control B (M=27.04), t (93) = 2.548, \( p = .012, \alpha = .05 \). Further Tukey HSD post-hoc tests were done to determine the significant mean difference between the four schools. The tests revealed that there is a significant mean difference between experimental school A and control school A (7.350), \( p = .0001 \) and between experimental school B and control School B (7.559), \( p = .0001 \). The first hypothesis, \( H_01 \): that there is no significant mean difference in student’s performance in Physics for Form two students’ taught Physics through practical work and those not exposed to practical work was rejected. Therefore the alternative hypothesis, \( H_1 \), there is a significant mean difference in student’s performance in Physics for Form two students’ taught Physics through practical work and those not exposed to practical work was accepted. The study concluded that the students exposed to practical work in Physics performed better than those taught through conventional method.

The second objective of the study was to establish the effects of practical work in Physics on students’ attitude change towards Physics. The results of the pretest attitude towards physics revealed that experimental school A (M = 3.60, SD = 9.880) had a higher mean attitude towards Physics than control A (M = 3.58, SD = 9.988). However, there was no any mean significance difference between the experimental school A and control school A, t (91) = 1.86, \( p = .853, \alpha = .05 \). The experimental school B (M =3.77, SD = 10.85) also had a higher mean attitude towards Physics than control school B (M = 3.65, SD = 9.853). However there was
no any mean significance difference between experimental school B and control school B, t (93) =1.482, ρ =.142, α = .05).

For the post-test, the study found out that the experimental school A (M = 3.90, SD = 10.710) had a higher mean attitude towards Physics score than the control school A (M = 3.65, SD = 10.291). The t-test revealed that there was a significant difference between experiment school set A and the control school set A, t (91) = 3.117, ρ =.002, α = .05. This implies that the experimental group taught Physics through practical work had a better attitude towards the subject than those taught through the conventional method.

The study further found out that the experimental school B had a higher mean attitude towards Physics (M =3.93, SD =10.159) than the control school B (M = 3.67, SD = 9.06). The t-test performed show that there was a significance mean difference between the two schools in sample set B in attitude towards Physics, t (93) =3.404, ρ =.001, α =.05).

The study also found out that there was a mean gain of +8.133 in the attitude scale for experimental school A which was significant, t (44) = 8.287, ρ =.001, α =.05. There was a similar case for experimental school B where there was a mean gain in students’ attitude towards Physics from pre-test and post-test of +4.565. This gain was significant absolute t (45) = 6.474, ρ =.0001, α =.05. However there was no significant mean gain in students’ attitude towards Physics for the control groups. For control School A, the mean gain was +1.729 which was not significant absolute t (47) = 3.222, ρ =.240, α =.05. For control school B, the mean gain was +1.000 which was also not significant, absolute t (48) = 2.078, ρ = .068, α = .05.
The study therefore rejected the second hypothesis $H_{02}$ that there was no significant difference in attitudinal change towards Physics for students’ taught Physics through practical work and those taught through conventional method. The study accepted the alternative hypothesis, $H_{02}$, there is a significant mean difference in attitudinal change towards Physics for students’ taught Physics through practical work and those taught through conventional method. There is a significant difference in attitude change towards Physics for students taught Physics through practical and those taught through conventional methods.

The third objective was to determine the effect of practical work in Physics on students’ acquisition of science process skills. To this end the science process skills investigated where the observation, drawing, manipulative, reporting and interpretative skills. The students’ proficiency in these five skills was determined using the observation checklists for skills. The study found out the experimental group in school category A performed better in the science process skills ($M = 57.29$, $SD = 14.533$) than the control group ($M = 43.71$, $SD = 9.015$). Similarly the experimental group in school category B also performed better ($M = 47.02$, $SD = 13.046$) than the control group ($M = 39.02$, $SD = 7.603$).

The fourth objective was to determine the effects of practical work in Physics on students’ enrolment in Physics. To this end, the number of students enrolled in Physics in form three was compared for the experimental and control groups in categories A and B. The study revealed that majority 17(37.7%) of the students in experimental school A enrolled for Physics compared to 11(22.9%) from the control school A. Similarly, majority 16(34.8%) from the experimental school B enrolled to
pursue Physics in Form Three compared to only 9 (18.4%) students who enrolled from the control school in category B. The study found out the there was a significant positive correlation between the students’ attitude towards Physics and their enrolment for the experimental groups. For the experimental group in category A schools, \( r (45) = .26, \rho = .043, \alpha = .05 \) while that of category B schools was \( r (46) = .18, \rho = .032, \alpha = .05 \). For the control groups there is in a weak positive relationship between students’ attitude and enrolment. For the control school in category A, \( r (48) = .06, \rho = .097, \alpha = .05 \) while that of category B, \( r (49) = .079, \rho = .81, \alpha = .05 \).

The above results show that practical work influenced the students’ attitude towards Physics which in turn lead to higher enrolment in Physics. The study therefore concluded that there is a significant difference in enrollment in Physics for the students taught through the conventional method. Therefore, the null hypothesis \( H_0 \), that there is no significant difference in enrolment in Physics for Form Two students taught Physics through Physics practical work and those not taught through practical work at Form 3, was rejected. The study accepted the alternative, \( H_a \), that there is a significant mean difference in enrolment in Physics for Form Two students taught Physics through Physics practical work and those not taught through practical work at Form 3 was accepted. The study concluded that teaching Physics through practical work had a positive effect on building a positive attitude towards Physics which in turn lead to higher enrolment.

The last objective was to develop a prototype marking scheme for evaluating practical work in Physics. The study found out that the scheme should evaluate the
Manipulative skills, such as observation skills, classification, inference skill, predicting, measuring and communicating.

5.3 Conclusions of the Study

The study made the following conclusions:

The first objective of the study was to establish the effects of practical work in Physics on student’s Performance in Physics. The study concluded that the students exposed to practical work in Physics performed better than those taught through conventional method.

The second objective of the study was to establish the effects of practical work in Physics on students’ attitude change towards Physics. The study concluded that there was a significant difference in attitude change towards Physics for students taught Physics through practical and those taught through conventional methods.

The third objective was to determine the effect of practical work in Physics on students’ acquisition of science process skills. The experimental groups had higher scores than the control groups in the science process skills. The study concluded that the students taught Physics through practical work acquired more science process skills than those taught Physics through the conventional method.

The fourth objective was to determine the effects of practical work in Physics on students’ enrolment in Physics. The study found out the students from the experimental groups had a higher enrolment than those from the control groups. The study concluded that enrolment in Physics was higher for those who were taught Physics through Practical work than those taught Physics through the conventional
method. The study concluded that teaching Physics through practical work had a positive effect on building a positive attitude towards Physics which in turn lead to higher enrolment and possibly achievements.

The last objective was to develop a prototype marking for evaluating practical work in Physics. The study found out that the scheme should evaluate the Manipulative skills such as observation skills, classification, inference skills, predicting measuring and communicating. This gives a wider spectrum in assessment unlike the conventional formats which are used in Physics assessment.

5.4. Recommendations

Following the above conclusions, the study made a number of recommendations to various stakeholders. They are divided into sections (1) for action and (2) for further study.

5.4.1 Recommendations for Action

1. The study has shown that practical approach improves performance, attitudinal change in the subject and improved acquisition of science process skills. It is therefore recommended that teachers should use the practical approach in the teaching of the subject because it leads to acquisition of science process skills, enhances students’ understanding and eventually better students’ performance in the subject. In addition, the practical approach to the teaching of the subject leads to the development of positive attitude towards the subject. This will eventually lead to higher enrollment of students in the subject at KCSE. This study is in line with recommendation of SMASE program. However, the study
recommends an evaluation by teachers of the science process skills as the practical activities are being carried out by the learners.

2. Secondly, the study recommends that the school administrators and the Boards of management should construct and equip Physics laboratories since the practical approach to teaching the subject demands such facilities.

3. The Kenya National Examination Council has also not been ignored. The study recommends piloting of the prototype marking scheme for evaluating acquisition of students’ science process skills in Physics. The current trend is marking only the final product, that is, the table of values filled after performing the experiment. However, the study recommends evaluating of the process just like it is done in music, home science and in foreign languages. Eventually, the marking scheme should be adopted. This would lead to de-stigmatization of the subject and hence higher enrollment in Physics.

5.4.2 Recommendations for Further Study

The study finally recommends areas for further research.

1. A laboratory is the key for practical approach. I therefore recommend that a study be conducted to find out the state of the laboratories in secondary schools in Kenya.

2. Enrolment that influence the science process skills in Physics on students’ performance in Physics.

3. Analysis of the impact of the Practical Approach in teaching Physics to a greater population or in other locales in Kenya.
REFERENCES

time degree programme of the faculty of education, Obafemi Awolowo

Agrawal, D. C., & Menon, V. J. (2010). Errors of observations and our
understanding of Physics. *Latin-American Journal of Physics

(1): 78-87.*

Akinbobola, A. O., & Afolabi, F. (2010). Analysis of Science process skills in West
African senior secondary school certificate Physics practical
Research, 5*, 234-240.

Alao, A. A., & Abubakar, R. B. (2010). Gender and academic achievements of
college Physics students: A case study of department of Physics/
Computer science education, Federal

secondary school teaching.* Glasgow: Bell & Bain Ltd.

representation by secondary school pupils in science.* Unpublished
Phd Thesis Kenyatta University.

Achievements and Enrolment in Secondary Schools in Western
Province: Implications for Strategy and Renewal, Problems of

of Original Computer Codes and Graphical Representations. *European


Board on Science Education, National Academy of Sciences. Washington DC.


Kola, A. (2013). Importance of science education to national development. *America journal of educational research, 1*(7), 223-229


Miles, E., (2010), In-Service Elementary teachers Familiarity, Interest, Conceptual Knowledge and Achievements on Science Process Skills, MSc (Educ) Theses, Open SIUC, pp (i)-(ii)


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## APPENDICES

### Appendix I: Candidature in the Science Subject Nationally between 2006 - 2009

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>243,453</td>
<td>276,239</td>
<td>305,015</td>
<td>337,404</td>
</tr>
<tr>
<td><strong>Entry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS</td>
<td>Entry</td>
<td>72,299</td>
<td>83,162</td>
<td>93,920</td>
</tr>
<tr>
<td></td>
<td>Entry %</td>
<td>29.69%</td>
<td>30.19%</td>
<td>30.79%</td>
</tr>
<tr>
<td>CHEMISTRY</td>
<td>Entry</td>
<td>236,831</td>
<td>263,719</td>
<td>296,937</td>
</tr>
<tr>
<td></td>
<td>Entry %</td>
<td>97.27%</td>
<td>96.91%</td>
<td>97.35%</td>
</tr>
<tr>
<td>BIOLOGY</td>
<td>Entry</td>
<td>217,675</td>
<td>248,519</td>
<td>274,215</td>
</tr>
<tr>
<td></td>
<td>Entry %</td>
<td>89.41%</td>
<td>89.96%</td>
<td>89.90%</td>
</tr>
</tbody>
</table>

Source: Kenya National Examination Council (2009)
### Appendix II: Candidates Overall Achievements in Physics Nationally between 2008 - 2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Paper</th>
<th>Candidature</th>
<th>Maximum Score</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Paper 1 232/1</td>
<td>72,299</td>
<td>80</td>
<td>24.00</td>
<td>15.62</td>
</tr>
<tr>
<td></td>
<td>Paper 2 232/2</td>
<td>80</td>
<td>35.75</td>
<td>17.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practical paper 232/3</td>
<td>40</td>
<td>20.88</td>
<td>7.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>200</td>
<td>80.63</td>
<td>37.00</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>Paper 1 232/1</td>
<td>83,162</td>
<td>80</td>
<td>23.46</td>
<td>13.43</td>
</tr>
<tr>
<td></td>
<td>Paper 2 232/2</td>
<td>80</td>
<td>23.33</td>
<td>17.93</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practical paper 232/3</td>
<td>40</td>
<td>25.85</td>
<td>17.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>200</td>
<td>82.62</td>
<td>35.00</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Paper 1 232/1</td>
<td>93,692</td>
<td>80</td>
<td>25.32</td>
<td>14.66</td>
</tr>
<tr>
<td></td>
<td>Paper 2 232/2</td>
<td>80</td>
<td>24.17</td>
<td>16.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practical paper 232/3</td>
<td>40</td>
<td>23.92</td>
<td>7.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>200</td>
<td>73.42</td>
<td>35.43</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Paper 1 232/1</td>
<td>104,883</td>
<td>80</td>
<td>26.72</td>
<td>16.17</td>
</tr>
<tr>
<td></td>
<td>Paper 2 232/2</td>
<td>80</td>
<td>20.77</td>
<td>14.23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practical paper 232/3</td>
<td>40</td>
<td>15.22</td>
<td>6.29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>200</td>
<td>62.62</td>
<td>34.02</td>
<td></td>
</tr>
</tbody>
</table>
Appendix III: Candidature for science subjects in Murang’a East Sub-county 2012

<table>
<thead>
<tr>
<th>Candidature</th>
<th>Subject</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1666</td>
<td>Physics</td>
<td>651</td>
<td>39.07</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>1611</td>
<td>96.69</td>
</tr>
<tr>
<td></td>
<td>Biology</td>
<td>1200</td>
<td>72.02</td>
</tr>
</tbody>
</table>

Source: Murang’a East Sub-County Quality Assurance of standard Paper 2012
Appendix IV: Students’ Enrolment in Physics in KCSE for the Participating Schools between 2011-2013

<table>
<thead>
<tr>
<th>School Category</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Experimental</td>
<td>22</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>Control</td>
<td>18</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>B Experimental</td>
<td>21</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Control</td>
<td>25</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: Murang’a District Education Office (2013)
Appendix V: An Example of a Prototype Marking Scheme for Practical Work in Physics

The Principle of Moments

By the end of the lesson the learner should be able to state and verify the principle of moments

Experiment: To verify the principle of moments

Apparatus: - metre ruler, known masses, string, retort stand

Procedure

1. Balance a meter ruler at its center using the string at its

2. Place a known mass \( W_1 \), on one end of the metre ruler and balance the metre ruler by placing a different known mass \( W_2 \) on the other side of the metre ruler as shown in the diagram.

3. Record the distance \( d_1 \) and \( d_2 \)

4. Repeat using different known masses for \( W_1 \) and \( W_2 \)

5. Complete the table below

<table>
<thead>
<tr>
<th>( W_1 )</th>
<th>( W_2 )</th>
<th>( d_1 )</th>
<th>( d_2 )</th>
<th>( W_1 \times d_1 )</th>
<th>( W_2 \times d_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Compare the value of \( W_1d_1 \) and \( W_2d_2 \)

7. Conclusion
A Marking Scheme (Confidential)

1. 2 marks for balancing the metre at its centre (manipulative skills)

2. 4 marks placing the masses as instructed (manipulative skill, observation, interpretative skills)

3. 4 marks for being able to make correct reading (observation reading)

4. 4 marks for being able to (manipulate the masses, recording, reporting)

5. Table 6 marks \(\frac{1}{2} \times 12 = 6\) work for each reading and \(\frac{1}{2}\) work for working out the product. (observation skills, recording, manipulation, reporting, reporting, measurement, accuracy)

6. 2 marks for correct answer and correct comment (reporting)

7. 2 marks for correct conclusion (interpretation inferring)

In a KCSE examination, 10 marks awarded are those for correct readings on the table and conclusion. However, the prototype marking scheme has an overall marks of 24. This shows the need to recognize the observation, recording and measurement skills which are not usually considered during KCSE examination marking.

This type of assessment which can be called performance assessment is more effective for science subjects. It assesses the student as he/she performs the experiment and it is more comprehensive and rewarding to the student.
Appendix VI: Pre-Test

**Answer all the questions in the paper**  
**Time: 1½ hours**

To be administered to all Groups before Experiment Begins

1. Fill in the table below the basic quantities measured in Physics, their SI units and symbol  
   (3mks)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>SI Unit</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kilogram</td>
<td>Kg</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>N</td>
</tr>
</tbody>
</table>

2. The following readings were taken using a metre rule. Indicate the reading at each of the pointers AB and C.  
   (3mks)

   A = 
   B = 
   C =

3. A thin thread 100cm wraps round a cylinder 20 times with the windings touching and not overlapping. Find the radius of the cylinder.(give your answer to 2 decimal places)  
   (2mks)

   ........................................................................................................................................
   ........................................................................................................................................
   ........................................................................................................................................

4. Convert the following

   a) 0.75m$^2$ into cm$^2$  
   (1mk)

   ........................................................................................................................................
   ........................................................................................................................................
   ........................................................................................................................................
b) 0.005mm$^2$ into cm$^2$  
..........................................................  ..........................................................  
..........................................................  ..........................................................  
..........................................................  ..........................................................  
(1mk)

c) 250km$^2$ into m$^2$  
..........................................................  ..........................................................  
..........................................................  ..........................................................  
..........................................................  ..........................................................  
(1mk)

5. Find the area of the figure below in m$^2$  
(2mks)

6. Briefly describe how you could determine the volume of a stone which has irregular shape.  
(4mks)

7. Define density  
(1mk)

8. A block of glass of mass 187.5g measures 5.0cm x 2.0cm x 7.5cm. Calculate the density of the glass in SI units.  
(3mks)
9. The mass of an empty bottle is 20g, its mass when filled with water is 40.0g and 50.0g when filled with liquid X. Calculate the density of liquid X given that the density of water is 1000kg/m$^3$. (4mks)

10. 250cm$^3$ of liquid (A) of density 0.5g/cm$^3$ is mixed with 150cm$^3$ liquid (B) of density 1.2g/cm$^3$. Determine the density of the mixture. (4mks)

11. Define force and state SI units (1mk)

12. List 4 types of forces (2mks)

13. State 3 effects of forces (3mks)

14. (a) Write down the explanation to the observation of experiments below. When a glass tube is dipped in water in a beaker it rises up in the glass tube but when dipped in a mercury the level of the mercury falls in the glass tube (1mk)

(b) It is easier to pull a block of wood on rollers than on the table (1mk)
(c) When a pen is rubbed on the hair it picks pieces of papers (1mk)

(d) When a small copper wire which is denser than water is placed gently on the water surfaces it floats (1mk)

(e) When a brush is dipped in water, its bristles springs out but when outside the water, the bristles cling together (1mk)

15. Write down the difference between a vector and a scalar quantity and give an example in each case (2mks)

16. In each of the following forces, give the resultant force. (2mks)

\[ \begin{align*}
7N & \quad 9N \\
3N & \quad 10N \\
4N & \\
\end{align*} \]

17. Define pressure and state its SI units. (2mks)

18. The density of mercury is 13600kgm\(^{-3}\). Determine the pressure at 76cm below the surface of the mercury. (3mks)

19. Calculate the maximum and minimum pressure of a 120kg mass that measures 40cm by 30cm by 60cm. (3mks)
20. (a) Define cohesive force and adhesive force (2mks)

(b)(i) A spring stretches by 6cm when supporting a load of 15N. By how much would it stretch when supporting a load of 5N. (2mks)

(ii) What load would make the spring extended by 25mm? (2mks)

21. A mass of 7.5kg weighs 30N on a certain planet. Calculate the acceleration due to gravity on this planet. (2mks)

22. (a) Define surface tension (1mk)

(b) How does temperature rise and impurities affect the surface tension of water? (2mks)

(c) How would the surface tension of water be increased? (2mks)
Appendix VII: Post Test

Answer all questions in this paper     Time: 40 minutes
To be administered to both Groups at the end of every topic

SECTION A: MOMENT AND FORCE

1. Define the moments of a force and state its SI units.   (2mks)

2. (a) Explain why it is easier to loosen a tight nut using a spanner with a long handle than one with a short handle (1mk)

(b) The handle of a door is usually placed as far as possible from the hinges. (1mk)

3. A uniform meter ruler is balanced at its centre point. An object weighing 20N is placed 10cm from the ruler’s midpoint on the right. Calculate the force that can balance the metre ruler as from zero mark

4. Two masses weight 200N and 500N are suspended at the end of a rod 5m long. Determine the position of the pivot from the 200N mass (3mks)

5. State the principle of moments (1mk)

6. Calculate the weight of the uniform beam, assuming that its weights acts through the centre of the beam which is in equilibrium
7. (a) State four application of antiparallel forces

(b) Define the term antiparallel forces

8. Calculate the unknown distance in the diagram which is in Equilibrium (2mks)

9. (a) A student wanted to investigate upthrust in a liquid and set-up the apparatus as shown in the figure below
2 masses of 100g each are suspended on either side of the pivot. One of the masses is immersed in a liquid and balances 50cm from the pivot while the other one is suspended in air and balances at 30cm from the same pivot. Determine the upthrust of the liquid. 

10. Sewe weighs 600N and sits 4m from the pivot of a seesaw. Silvia weighs 900N sits 3m from the pivot. By calculation who of the 2 will move up

11. (a) The figure below shows a wooden block of mass 2kg balanced by 3 forces. Determines the value of mass $M$, $3mg$ and the tension $T$ 

(b) What is the tension $T$ of the string suspending the system

(c) A wooden block is balanced from both ends by 16N and 24N. Determine where the pivot will be.
SECTION B: CENTRE OF GRAVITY AND EQUILIBRIUM

1. State two conditions for a system to be at equilibrium. (2mks)

2. (a) Define centre of gravity (1mk)

(b) Equilibrium (1mk)

3. (a) State and explain the factors affecting stability of any object (4mks)

(b) State and explain two applications of stability (4mks)

4. (a) Explain why it is not safe for a double Decker bus to carry standing passengers on the upper Decker. (3mks)

(b) Laboratory stands are made with a wide heavy base (2mks)

(c) Bus body builders have luggage compartments below seats rather than on roof racks (2mks)
5. (a) Name the three states of equilibrium

(b) Using diagrams, distinguish between the states named above.

6. Explain the significance of the centre of gravity

7. a) Explain clearly how you would determine the centre of gravity of your exercise book.

b) Explain why a very tall person is less stable compared to a short person

SECTION C: MAGNETISM

1. (a) State law of magnetism

(b) List three properties of magnetic field lines

(c) Explain how you would determine the polarity of the induced magnetism in a solenoid

2. Use magnetic domain theory to distinguish between magnetized magnetic material, unmagnetised magnetic materials and saturated magnets.
3. Use a diagram to explain how you will plot magnetic field line using a plotting campus (4mks)

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

4. Define the following terms
(a) Magnetic field (2mks)
……………………………………………………………………………………
……………………………………………………………………………………
(b) Direction of magnetic field lines (2mks)
……………………………………………………………………………………
……………………………………………………………………………………

5. Other than electrical method, name two methods used to magnetize magnetic materials (2mks)
……………………………………………………………………………………
……………………………………………………………………………………

6. Name 2 application of magnets (2mks)
……………………………………………………………………………………
……………………………………………………………………………………

7. The diagram below show two pins attached to the north pole of a magnet

What would happen if the pins are brought close together? Explain your answer (2mks)
……………………………………………………………………………………
……………………………………………………………………………………
8. Give two characteristics of the line of force (2mk)
……………………………………………………………………………………
……………………………………………………………………………………

9. Explain the Dommain theory of magnetism (3mks)
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

SECTION D: REFLECTION OF CURVED SURFACES

1. The image of an object placed 10cm from a concave mirror is formed 40cm from the mirror. Determine the focal length of the mirror. (3mks)
……………………………………………………………………………………
……………………………………………………………………………………

2. An object 2cm tall is placed 15cm from a converging mirror of focal length 5cm so that it is perpendicular to and has one end on the principal axis of the mirror. Determine the location, height and character of the image (2mks)
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

3. a) Concave spherical mirror has a focal length of 10cm where must an object be placed in order to produce a real magnified image three times as tall as the object. (4mks)
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

b) How far and in what direction does the object need to be moved to produce a virtual image three times as tall as the object? (4mks)
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
4. A concave mirror produces a real image 1cm tall of an object 2.5mm tall placed 5cm from the mirror. Find the position of the image and the focal length of the mirror. (4mks)

5. A concave mirror has a focal length of 4cm and an object 2cm tall is placed 9cm away from it. Find the position and size of the image (4mks)

6. a) Two sets of results were obtained by different experiments for the same concave mirror. Calculate its focal length from each set of results

   Results (a); distance of real object = 30cm
   Distance of real image = 20cm
   Result (b); distance of real object = 8cm
   Distance of virtual image = -24cm (4mks)

b) Give at least two uses of curved mirrors. (2mks)

7. The image of an object placed 10cm from a curved mirror is formed 40cm from the mirror. Determine the focal length of the mirror. (2mks)
Appendix VIII: Marking Scheme for Pre-Test

MARKING SCHEME

1.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>SI Unit</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>metre</td>
<td>M</td>
</tr>
<tr>
<td>mass</td>
<td>Kilogram</td>
<td>Kg</td>
</tr>
<tr>
<td>Time</td>
<td>Seconds</td>
<td>S</td>
</tr>
<tr>
<td>Weight</td>
<td>Newton</td>
<td>N</td>
</tr>
</tbody>
</table>

2.

2.  

A = 2.45  
B = 3.00  
C = 4.75

3.

20 times = 100 cm  
I time = 100 x 1 = 5 cm  

\[2\pi D = 5 = D = \frac{5}{2\pi} = 0.796 \text{ cm}\]  

\[R = \frac{0.796}{2} = 0.398 \text{ cm}\]

4. (a)

0.75 m² into cm²  
1 m² = 10000 cm²  
0.75 m² → 0.75 x 10000 = 7500 cm²

(b) 0.005 mm² into cm²
100\,mm^2 = 1\,cm^2

0.005\,mm^2 \rightarrow \frac{1 \times 0.005}{100} = 0.00005\,cm^2

(c) 250\,km^2 \text{ into m}^2

1\,km = 1000\,m

1\,km^2 = 1000 \times 1000\,m^2

250\,km^2 = 250 \times 1000 \times 1000 = 250,000,000\,m^2

5.

\[\begin{array}{c}
\text{4cm} \\
\text{3cm} \\
\text{7cm} \\
\text{8cm} \\
\end{array}\]

\[8 \times 7 = 56m^2\]

\[3 \times 4 = 12cm^2\]

\text{Total} = 68\,cm^2

6. Fill a Ureka can with water and let the water settle. Tie the irregular body with a light string; place a measuring cylinder at the spout. Gently lower the irregular body into the can until it is totally immersed. Collect the water in the measuring cylinder and read the column of water collected. This is the volume of the object.

7. Mass per unit volume

8. \[\text{Density} = \frac{\text{mass}}{\text{Volume}}\]

\[\frac{187.5\,g}{5 \times 2 \times 7.5} = 2.5\,g/km/cm^3 = 2.5 \times 1000 = 2500\]

9. \[\text{mass of water} = 40\,g - 20\,g = 20\,g\]
mass of liquid = 50g - 20g = 30g

volume of water = \( \frac{20g}{1g/km^3} = 20cm^3 \)

\[ \text{Density of liquid} = \frac{30g}{20cm^3} = 1.5g/km^3 \]

10. 

\[ \text{Mass of } A = 250cm^3 \times 0.89g/cm^3 = 200g \]

\[ \text{Mass of } B = 150cm^3 \times 1.2g/cm^3 = 180g \]

\[ \text{Mass of mixture} = 380g \]

\[ \text{Volume of mixtures} = 250 + 150 = 400 \]

\[ \text{Density} = \frac{380}{400} = 0.95g/km^3 \]

11. Force is a push or a pull and the SI unit is Newton

12. Frictional, gravitational, tensional, adhesion & cohesion, surface tension, molecular, centripetal

13. 3 effects of forces

- Can cause motion
- Stop motion
- Increase speed of motion
- Reduce speed of motion

14. (a) Mercury has a greater cohesive force than adhesive force while water has a greater adhesive force than cohesive force

(b) Rollers reduce friction force

(c) This is due to electrostatic force

(d) Water has surface tension

(e) Surface tension does not exist inside the water
1. Quantity of matter in a body
2. Same everywhere
3. A scalar quantity
4. Measured by beam balance
5. ST Units - kg

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pull of gravity on a body</td>
</tr>
<tr>
<td>2. Change from place to place</td>
</tr>
<tr>
<td>3. A vector quantity</td>
</tr>
<tr>
<td>4. Measured using spring balance</td>
</tr>
<tr>
<td>5. SI unit - Newton’s</td>
</tr>
</tbody>
</table>

\[ 7N + 9N = 16N \]

\[ (4N + 10N) - 3N \]
\[ 14N - 3N = 11N \]

15. (a) Pressure is force acting normally/perpendicularly per unit area N/M² (Pascal).
   (b) \( 96kg \rightarrow N \)

\[ 96kg \times \frac{10N}{KG} = 690N \]

\[ \text{Area} = \frac{480}{100000} = 0.048m^2 \]

\[ P = \frac{F}{A} \]

\[ 960N \times 1000 \]

\[ \frac{0.048 \times 1000}{20000N/m^2} = 20kpa \]

16. \( p = hpg \)

\[ 0.06m \times 1360kg/m \times 10N/kg \]

\[ = 1360 \times 76 = 103360N/M^2 \]

17. Maximum
\[ P = \frac{F}{A} = \frac{1200 \times 10}{0.4 \times 0.3} = 10,000 N/m^2 \]

Minimum
\[ P = \frac{F}{A} = \frac{1200}{0.4 \times 0.6} = \frac{120000}{24} = \frac{1200 \times 100}{0.24 \times 100} = 5000 N/m^2 \]

18. (a) Cohesive – force of attraction between molecule of the same kind

Adhesive – Force of attraction between molecules of different kind

(b)(i) \[ F = KE \]
\[ \frac{15}{6} = \frac{K \times 6cm}{6} = 25n/cm \]
\[ \frac{50N}{25} = \frac{2525N/MxE}{2.5} = E = 20cm \]

(ii) \[ F = KE \]
\[ F = \frac{2.5N}{cm \times 2.5cm} = 6.25N \]

19. \[ W = MY \]
\[ y = \frac{w}{m} = \frac{30N \times 10}{75kg \times 10} = \frac{300}{75} = 4N/kg \]

20. (a) The force which causes the surface of a liquid to behave like a stretched elastic skin

(b) – with temperature rise, the kinetic energy at the molecules or a liquid is increase, intermolecular distance increases hence surface tension is lowered

Impurities reduce the surface tension detergents weaken the cohesive forces between liquid increases

(c) Reducing impurities
Appendix IX: Marking Scheme Post Test

MARKING SCHEMES

Time: 40 Minutes

1. It is the product of force and the perpendicular distance from the turning point to the line of action of the force, NM.

2. (a) The longer arm provides a higher moment as compared to the shorter one
   (b) To produce high moments to make the door easy to open and use less force.

3. \[ 50W = 20 \times 10 \]
   \[ w = \frac{20 \times 10}{50} = \frac{200}{50} = 4N \]

4. \[ 200x - 500(5 - x) \]
   \[ 200x = 2500 - 500x \]
   \[ 700x = 2500 \]
   \[ x = \frac{25}{7} = 3.57 \]

5. For a system at equilibrium the sum of clockwise moments about a point equals the sum of anticlockwise moment about the same point.

6. \[ \frac{5kg \times 10m}{30cm} = \frac{30m \times m}{30} \]
   \[ m = \frac{5}{3} kg = 1.667kg \times 10N/kg = 16.67N \]

7. (a) Application
   - Opening and closing a water tap
   - Opening a nut using a spanner
   - Steering wheel
   - Bicycle handle
   (b) These are forces acting parallel, equal and in opposite direction

8. Distance
   \[ (5x8) + (4.6 \times 2) = (4 \times 1.8) + 4.2(d + 4) \]
   \[ 40 + 9.2 = 7.2 + 4.2d + 16.8 \]
   \[ 49.2 - 24.0 = 24 + 4.2d = \frac{25.2}{4.2} = \frac{4.2}{4.2} \]
\[ d = \frac{252}{42} = d = 6c \]

9. \( 50\text{m} \times 1\text{N} \times 30\text{m} \) + \( 50\text{m} \times \text{V} \)
   
   \[ 50\text{Ncm} = 30\text{Ncm} + 50\text{cmV} \]
   
   \[ 50\text{Ncm} - 30\text{Nm} = 50\text{cmV} \]
   
   \[ 20\text{Nm} = \frac{50\text{cmV}}{50\text{cm}} \]
   
   \[ V = 0.4\text{N} \]

10. a) \( \text{cm} = 600\text{N} \times 4\text{m} = 2400\text{NM} \)
    
    \[ \text{ACM} = 900\text{N} \times 3\text{M} = 2700\text{NM} \]
    
    Silvia moves up

11. (a) \( 3 \times 12 = 2 \times 2 + 14\text{m} \)
   
   \[ 36 = 4 + 14\text{m} \]
   
   \[ 40 = 14\text{m} \]
   
   \[ m = \frac{40}{14} = 2.857 \]
   
   (b) \[ T = \frac{(3\text{kg}+2\text{kg}+2.857\text{kg}) \times 10\text{N}}{\text{KG}} \]
   
   \[ = 7.85\text{kg} \times 10 = 78.5\text{N} \]
   
   (c) \( 16x = 24(100 - x) \)
   
   \[ 16x = 2400 - 24x \]
   
   \[ 40x = 2400 \]
   
   \[ x = 60 \]
   
   \[ x = 40 \]

**SECTION B: CENTER OF GRAVITY AND EQUILIBRIUM**

1. The sum of the anticlockwise moments about a point is equal to the sum of anticlockwise moments about the same point. The sum of forces activity in one direction is equal to the sum of forces acting in the opposite direction

2. (a) The point through which the resultant weight of a body acts
   
   (b) The balanced state of a body. The sum of all the forces activity on a body is zero
3. Position of the centre of gravity – when position of COG is raised, the body becomes unstable while if lowered the body becomes more stable.

The base area of the body – a body becomes more stable with a wide base area.

(b) Bunsen Burner – it has a wider base area assisting it to stand upright.

Racing cars – they are built with a wider base areas enhancing their stability.

4. (a) It reduces the stability at the base because much weight is concentrated on the upper decker raising the position of COG hence lowering stability.

(b) The heavy base carries the COG, the large area increases its base area this ensuring the stability of the burner.

(c) To increase the weight of the base thus increasing the stability. Lowering the position of COG hence increasing stability.

5. (a) Stable, unstable and Neutral.

(b) A tall person has his centre of gravity very high from the ground compared to a short person whose centre of gravity is low.

SECTION C: MAGNETISM

1. (a) Law of magnetism is like poles repels and unlike poles attract.

(b) Properties
   - They do not meet
   - They originate from the north and end at the south.
They leave and meet the magnetic pole at right angles.

(c) Look at the solenoid and determine the direction of the current. If from the point facing you the current is clockwise that point is the South Pole. If it is anticlockwise then it is the North Pole.

2. Dipoles in most domains of a magnetized magnetic material are alighted in one direction.
   Dipoles in the domains of an un-magnetized magnetic material are arranged in a loop.
   Dipoles in all the domains of a saturated magnetic are aligned in one direction.

3. 

4. (i) Region within which magnetic influence is felt
   (ii) Direction which a north pole placed in a magnetic field would follow if free to do so.

5. Stoking and induction

6. Application
   - In hospitals to remove magnetic particles from the eye
   - In dynamos
   - Telephone receivers
   - Loud speakers
   - Electromagnetic

7. They repel. This is because like poles repels each other and unlike poles attract.

8. (i) Magnetic field lines go from the N pole to the South Pole
   (ii) The magnetic field has never cross each others.
SECTION D: REFLECTION OF CURVED SURFACES

1. \[
\frac{1}{f} = \frac{1}{v} + \frac{1}{u}
\]
\[
= \frac{1}{10} + \frac{1}{40} = 4 + 1 = \frac{5}{40} = \frac{1}{8}
\]

\[f = 8\text{cm}\]

2. \[U = 15 \text{ f}=5\]

\[
\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow \frac{1}{v} = \frac{1}{5} - \frac{1}{15} = \frac{3 - 1}{15} = \frac{2}{15}
\]

\[v = \frac{15}{2} = 7.5\text{cm}\]

\[m = \frac{v}{u} = \frac{7.5}{15} = \frac{1}{2}\]

\[
\frac{1}{2} = \frac{x}{7} \rightarrow x = 1
\]
\[\therefore \text{ The image is } 1\text{cm tall, it is real image}\]

3. (a) \[F = 10\text{cm}\]

\[m = \frac{v}{u} \rightarrow 3\frac{v}{u} \rightarrow 3u = v\]

\[
\frac{1}{f} = \frac{1}{u} + \frac{1}{v}
\]

\[
\frac{1}{10} = \frac{1}{u} + \frac{1}{3u} \rightarrow \frac{1}{10} = \frac{3 + 1}{3u} = \frac{4}{3u}
\]

\[3u = 40\]

\[u = 13.3\text{cm}\]

(b) If the image is virtual the \(v=\) will be negative

\[
\therefore \frac{1}{f} = \frac{1}{u} = \frac{1}{v} = \frac{1}{10} = \frac{1}{u} - \frac{1}{3u} \rightarrow \frac{1}{10} = \frac{3 - 1}{3u}
\]

\[\frac{2}{3u} = \frac{1}{10} \rightarrow \frac{20}{3u} \rightarrow u = 6.6\text{cm}\]

The object will have to be moved \(13.3-6.6=6.7\text{cm}\) towards the mirror.

4. Magnification = \[\frac{\text{Image Distance}}{\text{Object Distance}}\]

\[\frac{1}{0.25} = \frac{\text{Image Distance}}{5}\]
Image Distance \( \frac{5}{0.25} = 20\text{cm} \)

\[ v = 20\text{cm}, u = 5\text{cm} \]

\[
\frac{1}{f} = \frac{1}{u + \frac{1}{v}} \rightarrow \frac{1}{f} = \frac{1}{5 + \frac{1}{20}} = \frac{1}{f}
\]

\[
\frac{1}{f} = \frac{1 + 4}{20} = \frac{5}{20}
\]

\[ f = 4\text{cm} \]

5. \( f = U\text{cm}, U = 9\text{cm} \)

\[
\frac{1}{f} = \frac{1}{u + \frac{1}{v}} \rightarrow \frac{1}{v} = \frac{1}{4} - \frac{1}{9} = \frac{9 - 4}{36} = \frac{5}{36}
\]

\[ v = \frac{36}{5} = 7.8\text{cm} \]

\[ m = \frac{v}{u} = \frac{78}{9} = 0.8 \]

\[ 0.8 = \frac{x}{2} \]

\[ x = 0.8 \times 2 = 1.6\text{cm tall} \]

6. a) \( \frac{1}{f} = \frac{1}{u} + \frac{1}{v} \)

\[
\frac{1}{f} = \frac{1}{30} + \frac{1}{20}
\]

\[
\frac{2 + 3}{60} = \frac{5}{60} = \frac{1}{12}
\]

\[ f = 12\text{cm} \]

b) Calculate

\[
\frac{1}{f} = \frac{1}{u} + \frac{1}{v}
\]

\[
\frac{1}{f} = \frac{1}{8} + \frac{1}{24}
\]

\[
\frac{3 - 1}{24} = \frac{2}{24} = \frac{1}{12}
\]

\[ f = 12\text{cm} \]

c) - used as shaving mirror

- used as driving mirror
### Appendix X: Students Physics Attitudes Scale (SPAS)

Instructions: These are statements about your attitude toward Physics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Place a tick at the most closely corresponds to how each statement best describes your feelings. Answer every question. Tick (√) where appropriate

<table>
<thead>
<tr>
<th>Statements</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Physics is a very worthwhile and necessary subject.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2  I want to develop my Physics skills.</td>
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<tr>
<td>3  Physics helps develop the mind and teaches a person to think.</td>
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<td>4  Physics is important in everyday life.</td>
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<td>5  Physics is one of the most important subjects for people to study.</td>
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<td>6  I can think of many ways that I use Physics outside of school.</td>
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<td>7  Physics is one of my most dreaded subjects.</td>
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<tr>
<td>8  My mind goes blank and I am unable to think clearly when working with Physics.</td>
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<tr>
<td>9  Studying Physics makes me feel nervous.</td>
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<tr>
<td>10 Physics makes me feel uncomfortable.</td>
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<tr>
<td>11 I am always under a terrible strain in a Physics class.</td>
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<tr>
<td>12 When I hear the word Physics, I have a feeling of dislike.</td>
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<tr>
<td>13 It makes me nervous to even think about having to do a Physics problem.</td>
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<tr>
<td>14 Physics does not scare me at all.</td>
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</tr>
<tr>
<td>15</td>
<td>I have a lot of self-confidence when it comes to Physics.</td>
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</tr>
<tr>
<td>16</td>
<td>I am able to solve Physics problems without too much difficulty.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>17</td>
<td>I am always confused in my Physics class.</td>
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<td></td>
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<tr>
<td>18</td>
<td>I learn Physics easily.</td>
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<tr>
<td>19</td>
<td>I have usually enjoyed studying Physics in school.</td>
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<td></td>
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<tr>
<td>20</td>
<td>Physics is dull and boring.</td>
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<tr>
<td>21</td>
<td>I would prefer to do an assignment in Physics than to write an essay.</td>
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<tr>
<td>22</td>
<td>I would like to avoid using Physics in college.</td>
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<tr>
<td>23</td>
<td>I really like Physics.</td>
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<tr>
<td>24</td>
<td>I am happier in a Physics class than in any other class.</td>
<td>p</td>
<td></td>
<td></td>
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<tr>
<td>25</td>
<td>Physics is a very interesting subject.</td>
<td></td>
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<tr>
<td>26</td>
<td>I am comfortable answering questions in Physics class.</td>
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<tr>
<td>27</td>
<td>I believe I am good at solving Physics problems.</td>
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</tbody>
</table>
### Appendix XI: Observation Checklists for Skills Acquisition (OCFSA) for Form Two

This is an observation checklist for skills acquired during the achievements of Physics experiments. Tick (✓) where appropriate

<table>
<thead>
<tr>
<th>Topic 1</th>
<th>Magnetism</th>
<th>Not Able</th>
<th>To a Small Extent</th>
<th>Needs Teacher’s Assistance</th>
<th>Perfectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science process skill</td>
<td>Observing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measuring</td>
<td></td>
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<tr>
<td></td>
<td>Classifying</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Recording</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental achievements skills</td>
<td>Setting up apparatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading scales on apparatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manipulation of experimental data</td>
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Appendix XII: Research Authorization Letter

NATIONAL COMMISSION FOR SCIENCE,
TECHNOLOGY AND INNOVATION

NACOSTI/P/15/5262/4724

Augustine Nyechie Muchai
Kenyatta University
P.O. Box 43844-00100
NAIROBI

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "Effects of practical work on students performance in physics at secondary school level in Murang'a East Sub County, Kenya," I am pleased to inform you that you have been authorized to undertake research in Murang'a County for a period ending 31st December, 2016.

You are advised to report the County Commissioner and the County Director of Education, Murang'a County, before embarking on the research project.

On completion of the research, you are required to submit two hard copies and one soft copy in PDF of the research report/thesis to our office.

DR. S. K. LANG'AT
FOR DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Murang'a County,

The County Director of Education
Murang'a County.

Appendix XIII: Approval of Research Proposal

Internal Memo

FROM: Dean, Graduate School

DATE: 21st September, 2014

TO: Dr. Kiarui Augustine Mgerehe

C/o Educational, Career & Tech Dept.
Kenya University

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board in its meeting of 17th September, 2014 approved your Research Proposal for the Ph.D. Degree. Subject to, revising your title to read, "Effect of Practical Work on Students’ Performance in Physics at Secondary School Level in Murang’a East County, Kenya".

Thank you.

REUBEN MURIUKI
FOR: DEAN, GRADUATE SCHOOL

Cc.: Chairman, Education, Communication and Technology Dept.

Supervisors:
1. Dr. Nicholas Nyoni
   C/o Education, Communication and Technology Dept.
   KENYATTA UNIVERSITY

2. Dr. David Kistache
   C/o Education, Communication and Technology Dept.
   KENYATTA UNIVERSITY
Appendix XIV: Research Permit

Mr. Augustine Ngethe Muchai
Director of KENYATTA UNIVERSITY, 0-1000

THKA has been permitted to conduct research in Muranga County

Date issued: 22nd January 2015
Fee Received: Ksh. 2000

Purpose of research:
- EFFECT OF PRACTICAL WORK ON STUDENTS PERFORMANCE IN PHYSICS AT SECONDARY SCHOOL LEVEL IN MURANGA EAST, SUB COUNTY KENYA.
- To determine the impact of practical work on students' performance in physics at secondary school level in Muranga East Sub County, Kenya.

Applicant:

Signature:

National Commission for Science, Technology and Innovation

Conditions:

1. You must report to the County Commissioner and the School Board before embarking on your research. Failure to do so may lead to the cancellation of your permit.

2. Government officers will not be interviewed without prior appointment.

3. No questionnaire will be used unless it has been approved by the County Education Officer of the area.

4. Excavation, filing, and collection of biological specimens are subject to further permission from other Government Ministries.

5. You are required to submit at least two (2) hard copies and one (1) soft copy of your final report.

6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.
Appendix XV: Map of Murang’a County